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(12) **United States Patent**
Huynh

(10) **Patent No.: US 9,188,408 B2**
(45) **Date of Patent: Nov. 17, 2015**

(54) **AUTO-LOCKING ADJUSTMENT DEVICE**

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(73) Assignee: **LEUPOLD & STEVENS, INC.**, Beaverton, OR (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 823 days.

(21) Appl. No.: **12/938,981**

(22) Filed: **Nov. 3, 2010**

(65) **Prior Publication Data**

US 2011/0100152 A1 May 5, 2011

Related U.S. Application Data

(60) Provisional application No. 61/258,190, filed on Nov. 4, 2009.

(51) **Int. Cl.**

G05G 5/12	(2006.01)
G05G 1/10	(2006.01)
F41G 1/38	(2006.01)
F41G 1/22	(2006.01)

(52) **U.S. Cl.**

CPC ... ***F41G 1/22*** (2013.01); *F41G 1/38* (2013.01); *G05G 1/10* (2013.01); *Y10T 74/2084* (2015.01); *Y10T 74/20474* (2015.01)

(58) **Field of Classification Search**

CPC F41G 1/22; F41G 1/54; F41G 1/38; F41A 33/02; G05G 5/03; G05G 1/082; Y10T 74/2084

USPC .... 74/504, 813 L, 553; 42/119, 126; 359/821; 70/214

See application file for complete search history.

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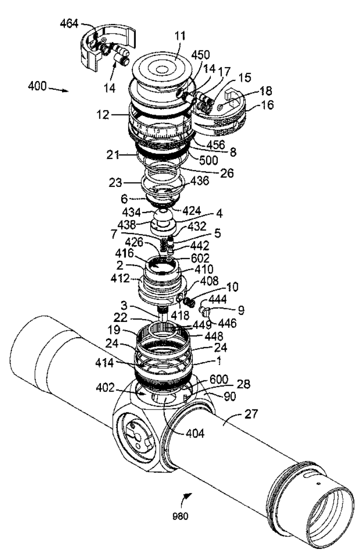
Primary Examiner — Vinh Luong

(74) *Attorney, Agent, or Firm* — Stoel Rives LLP

(57) **ABSTRACT**

A dial for adjusting an adjustable portion of a device includes an actuator that moves substantially transverse to an axis of rotation to unlock the dial for rotation. When the actuator is released, the dial automatically locks in place.

25 Claims, 22 Drawing Sheets



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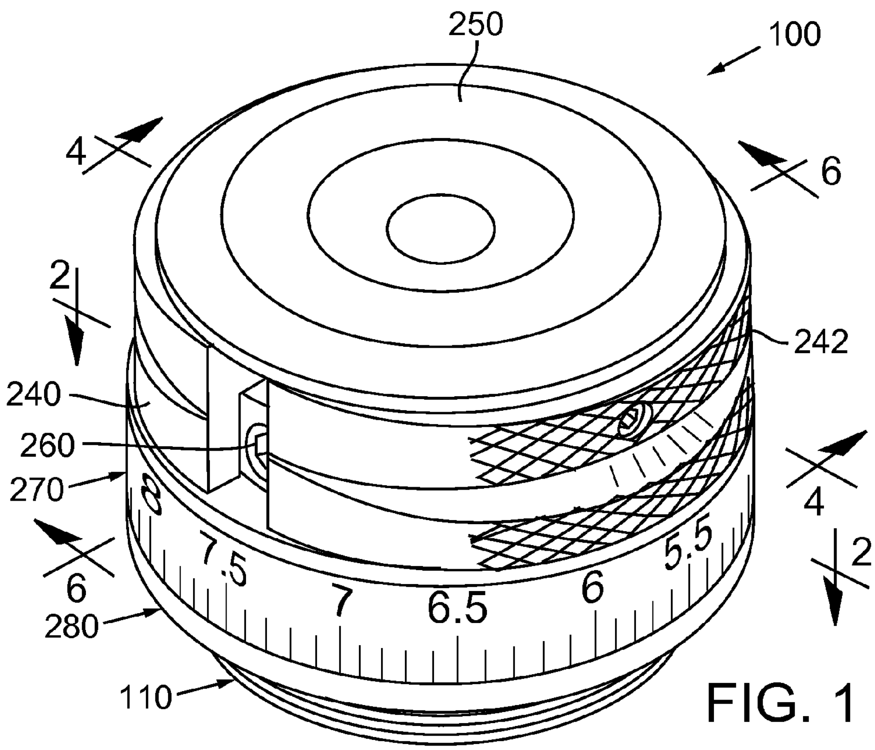
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FIG. 1

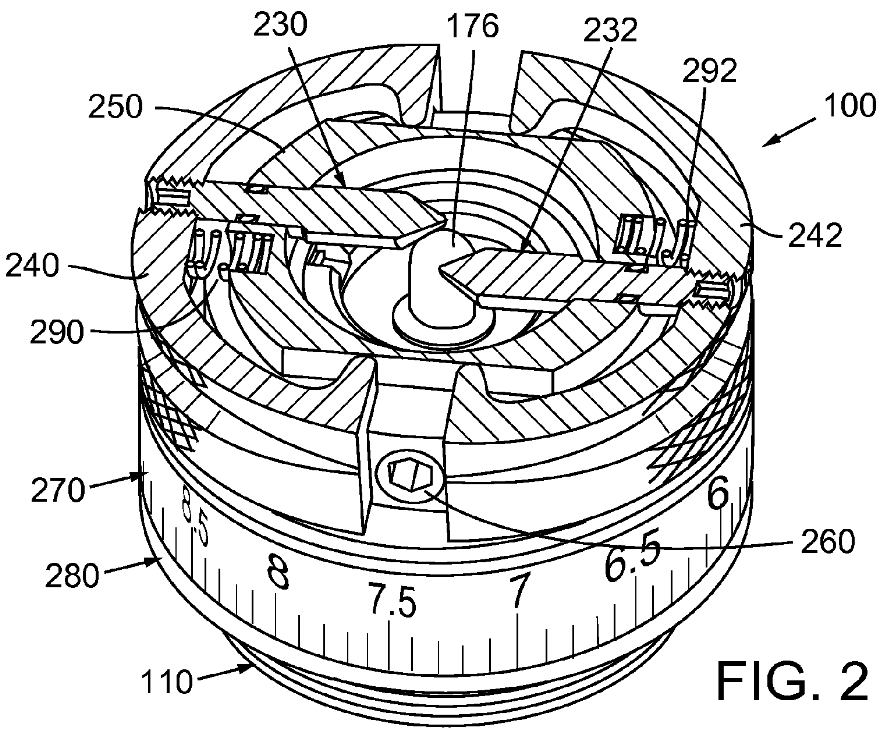
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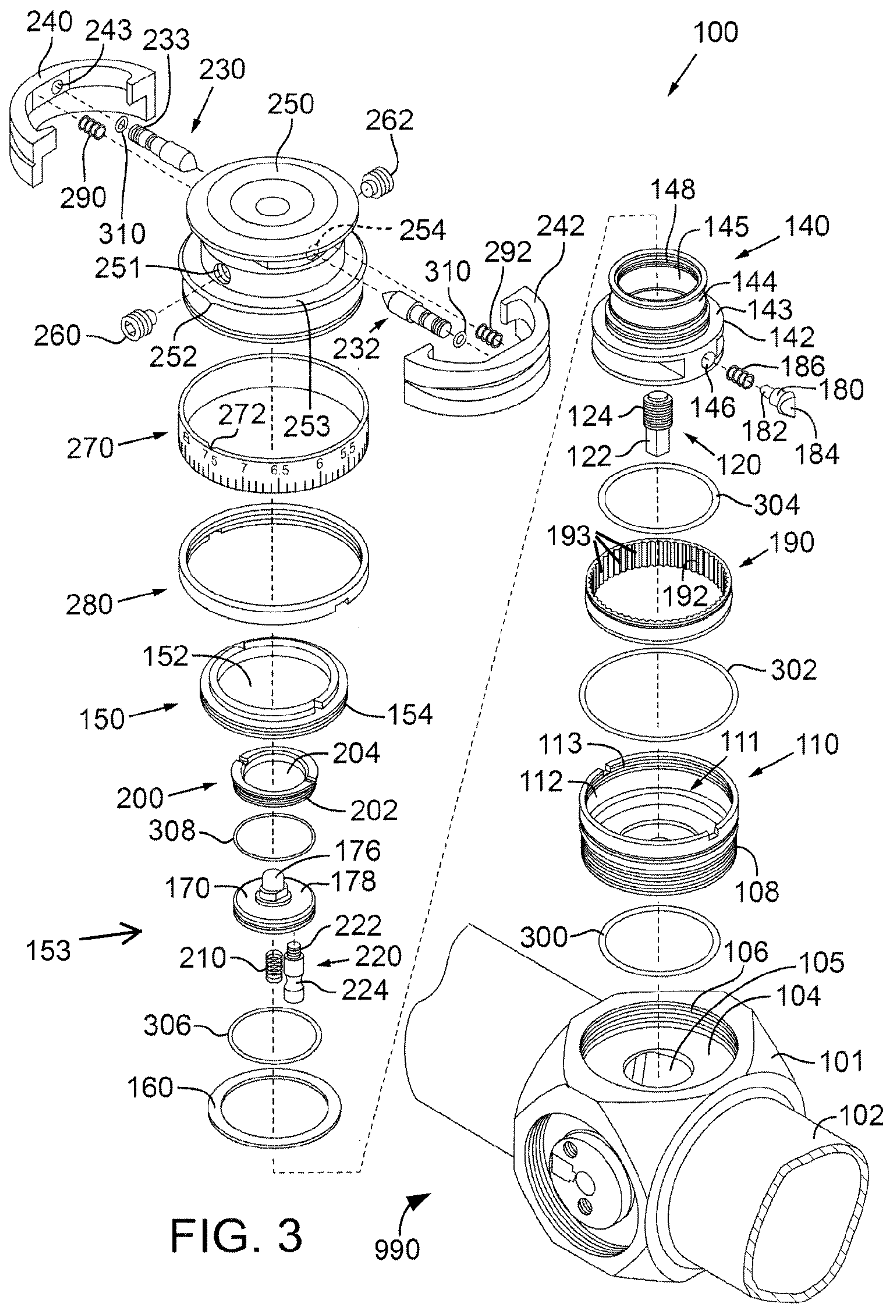
FIG. 2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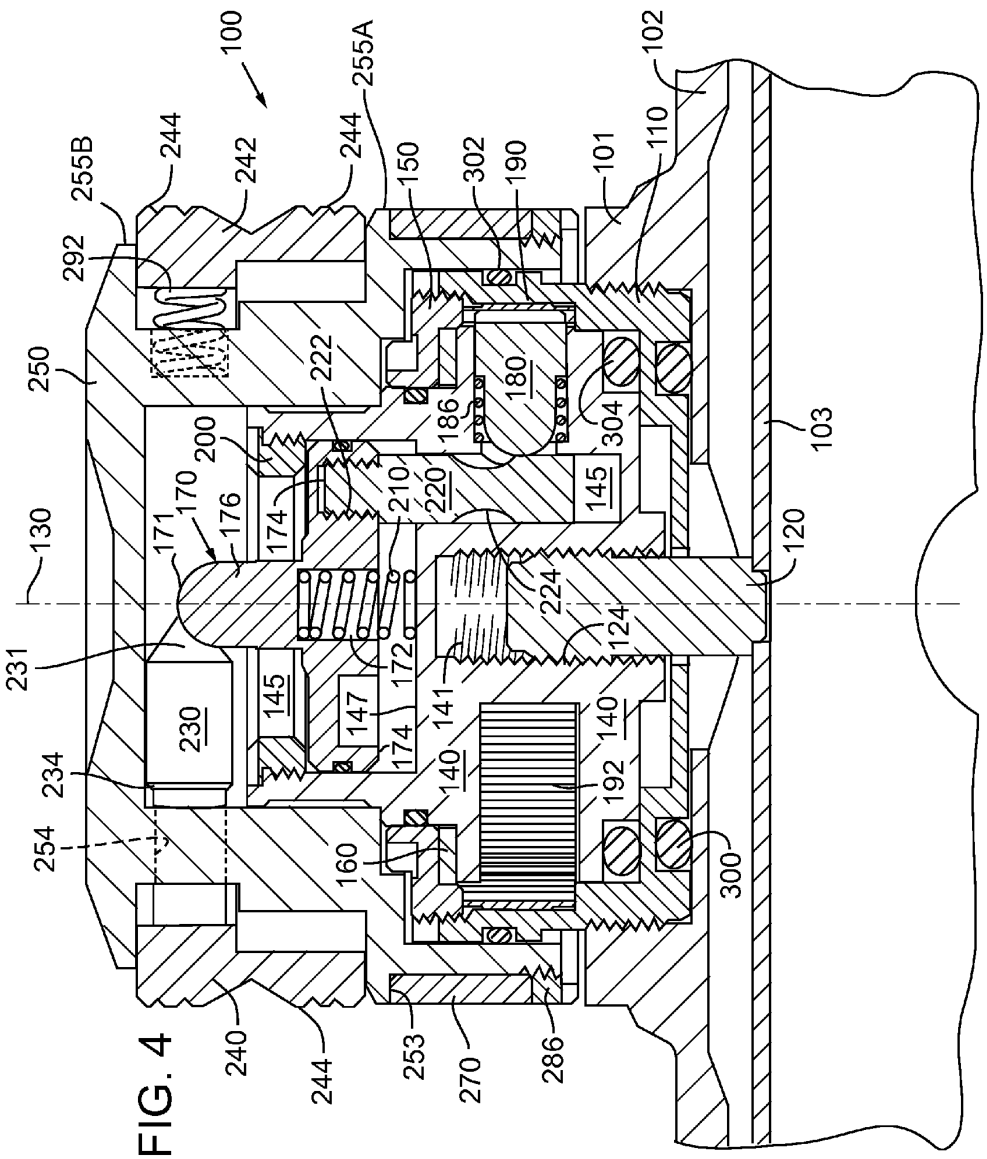
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FIG. 4

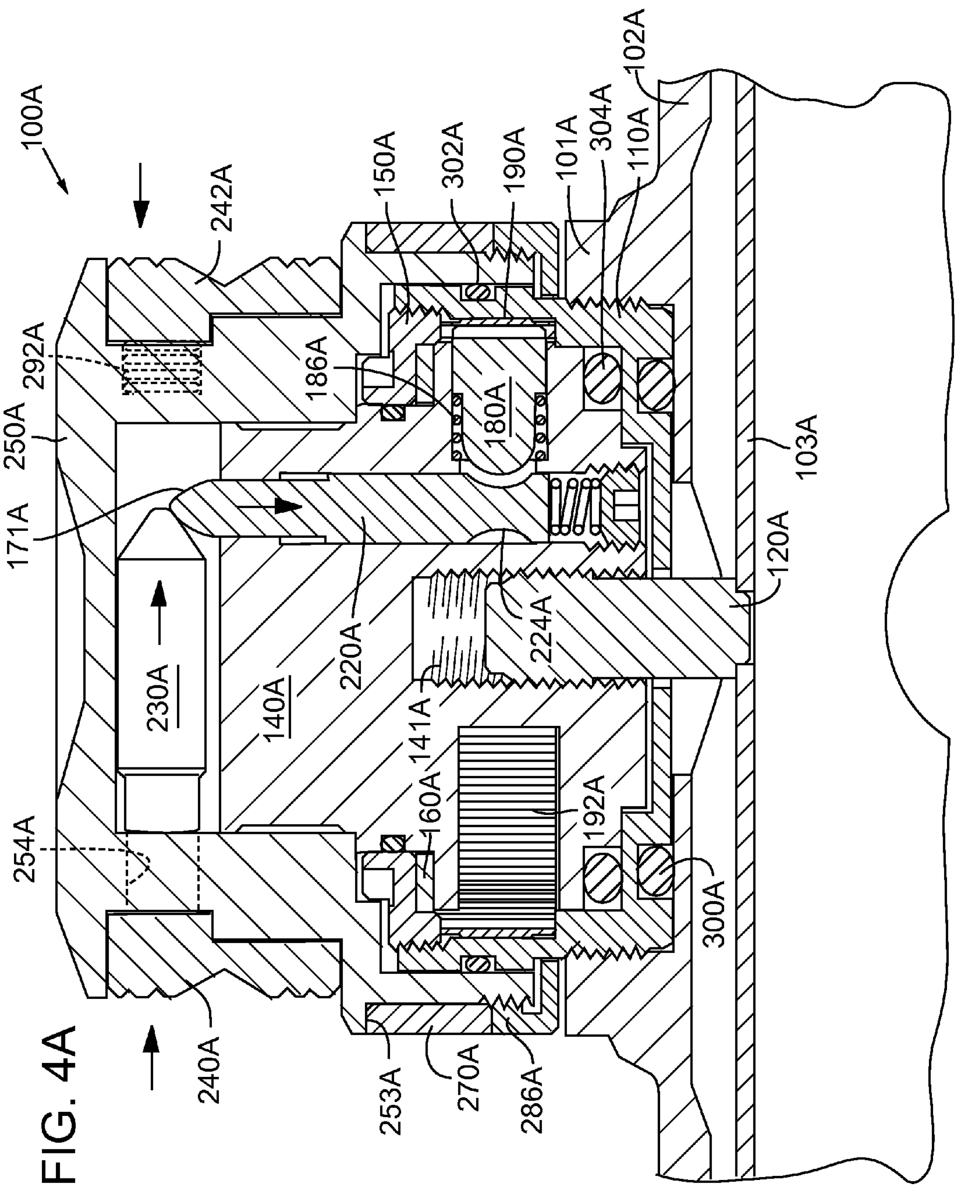
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FIG. 4A

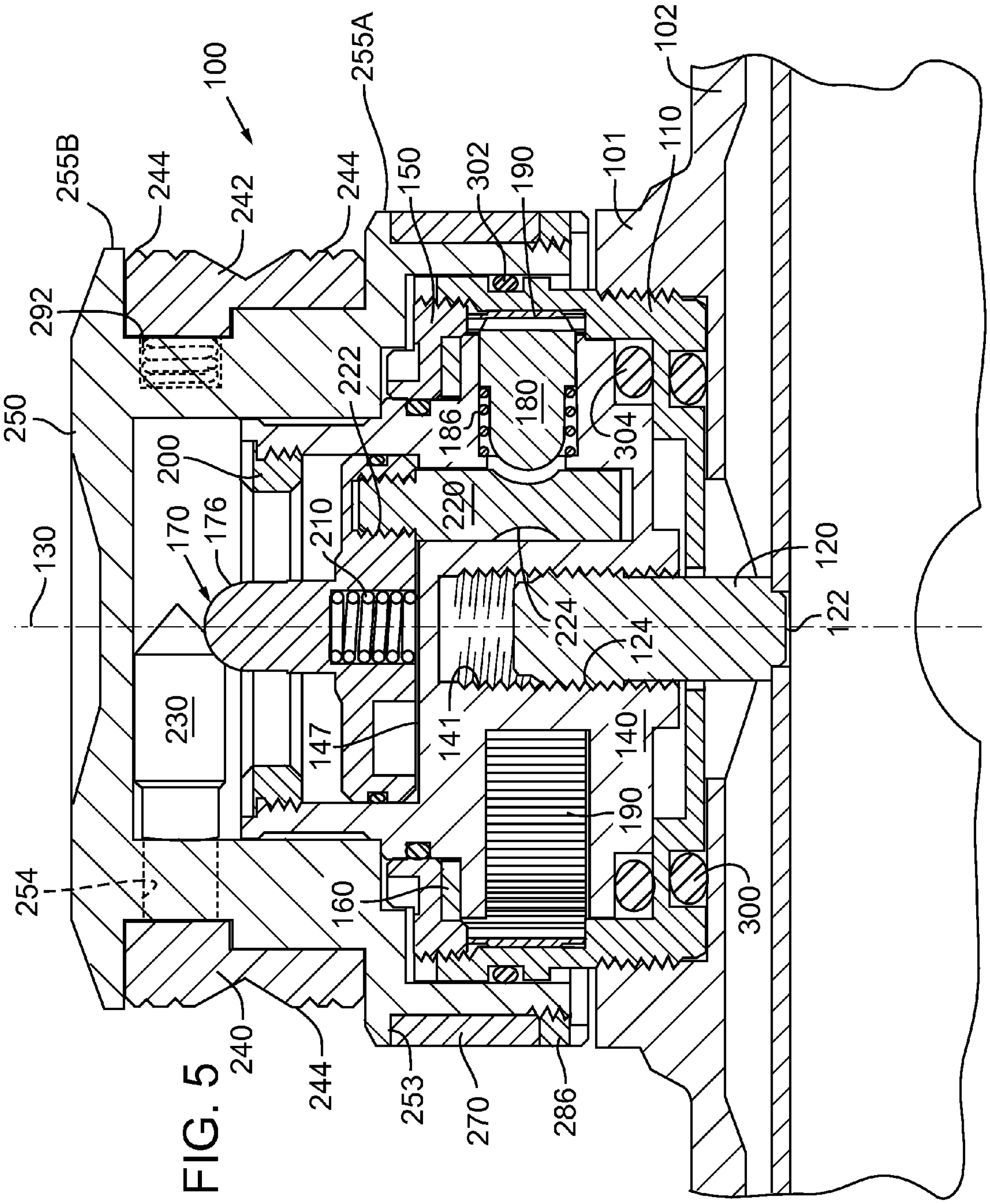

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FIG. 5

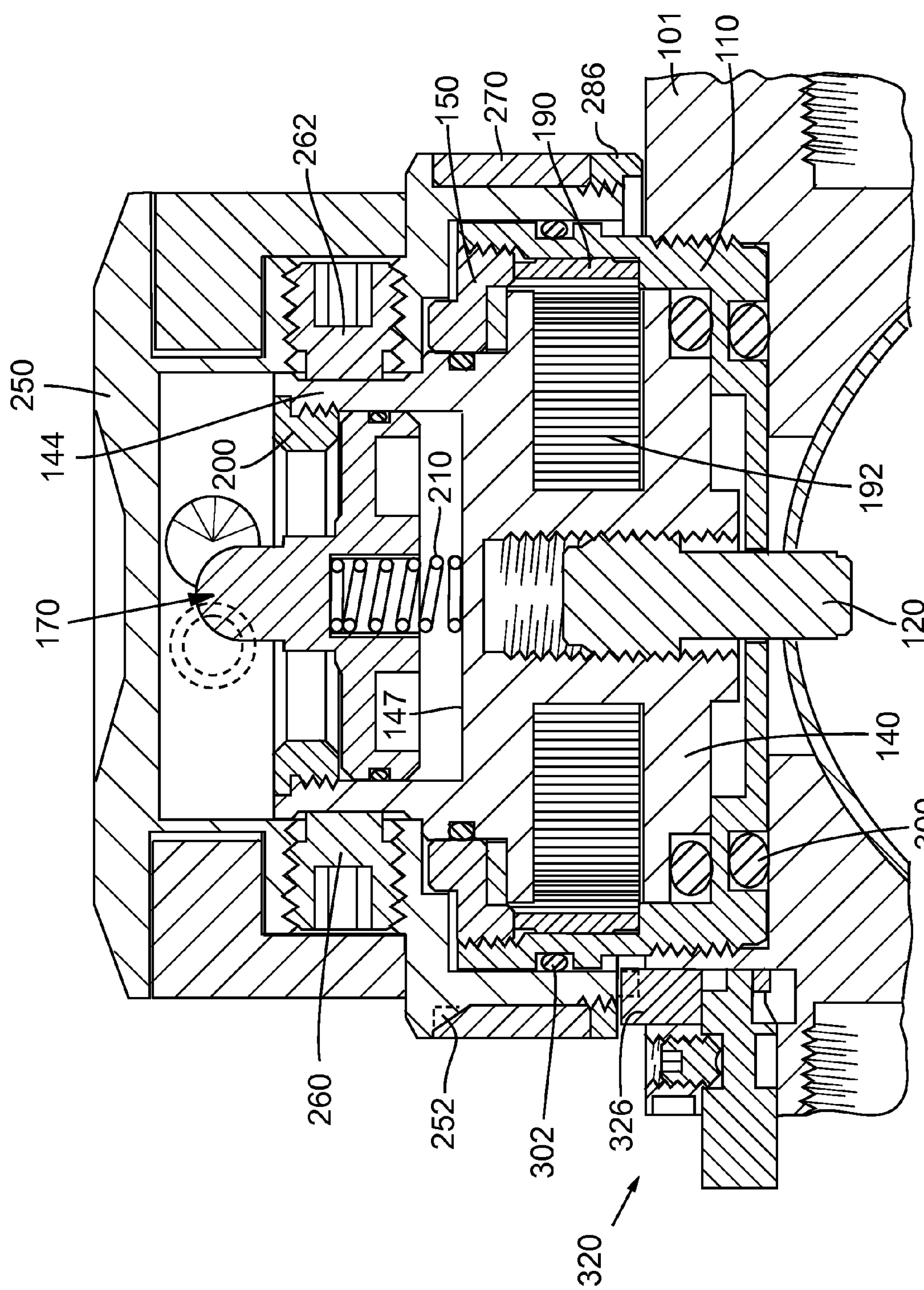
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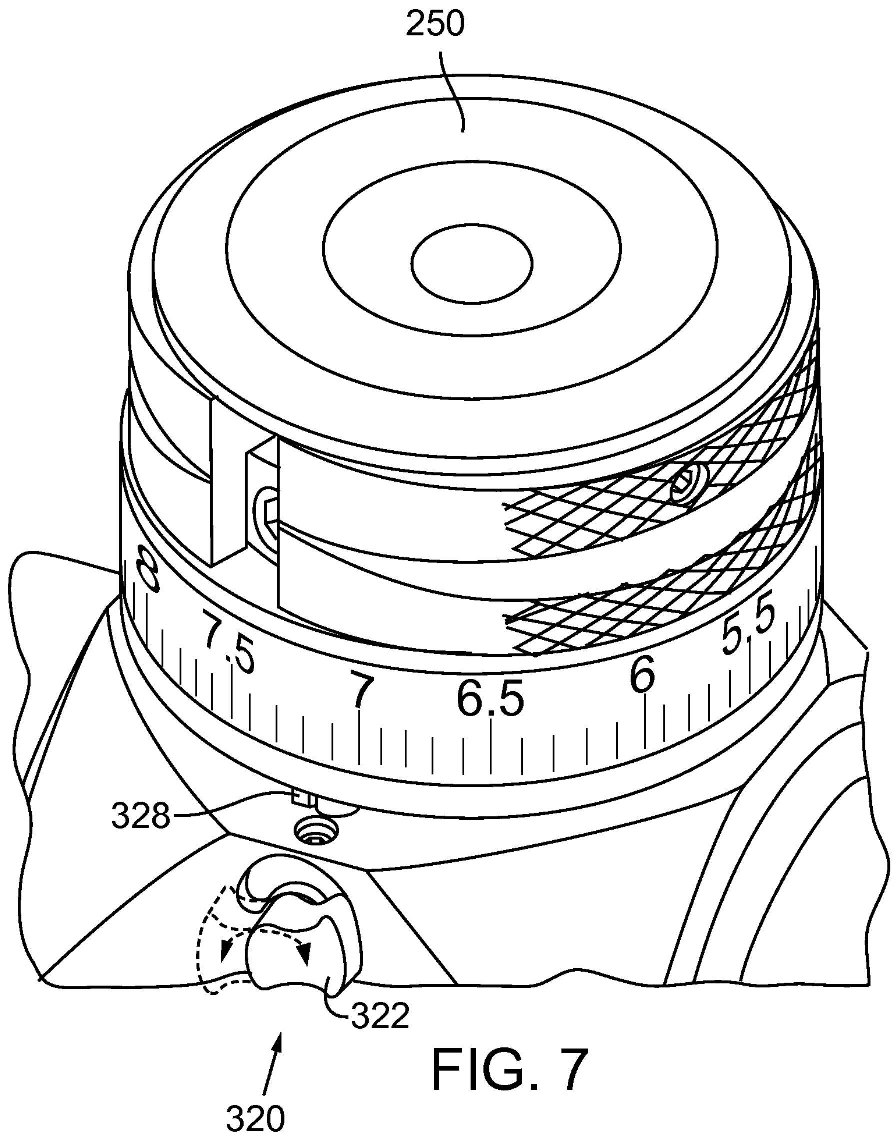
FIG. 6



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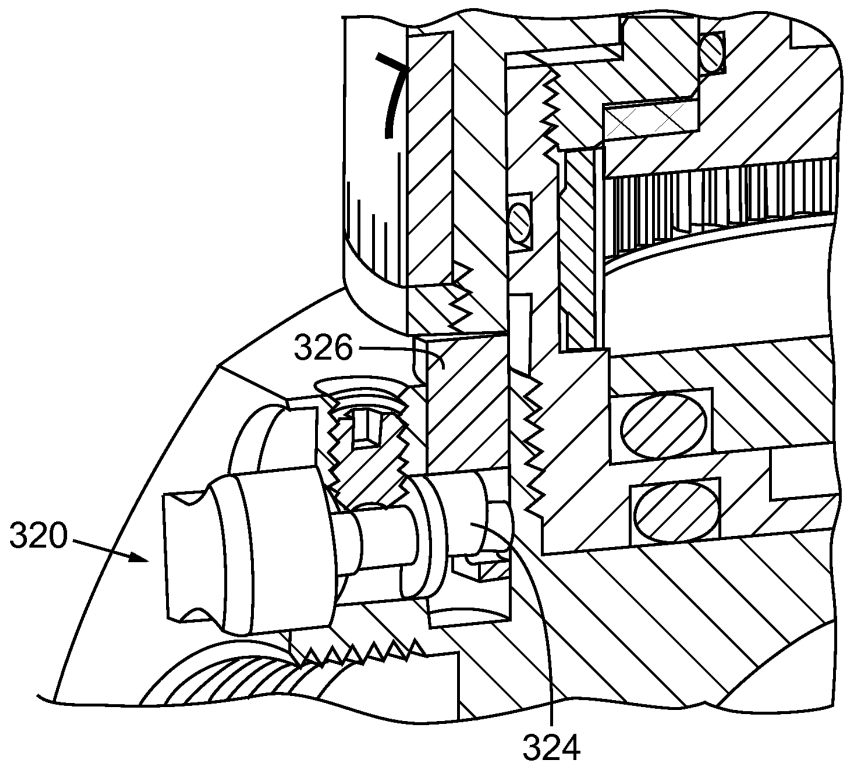

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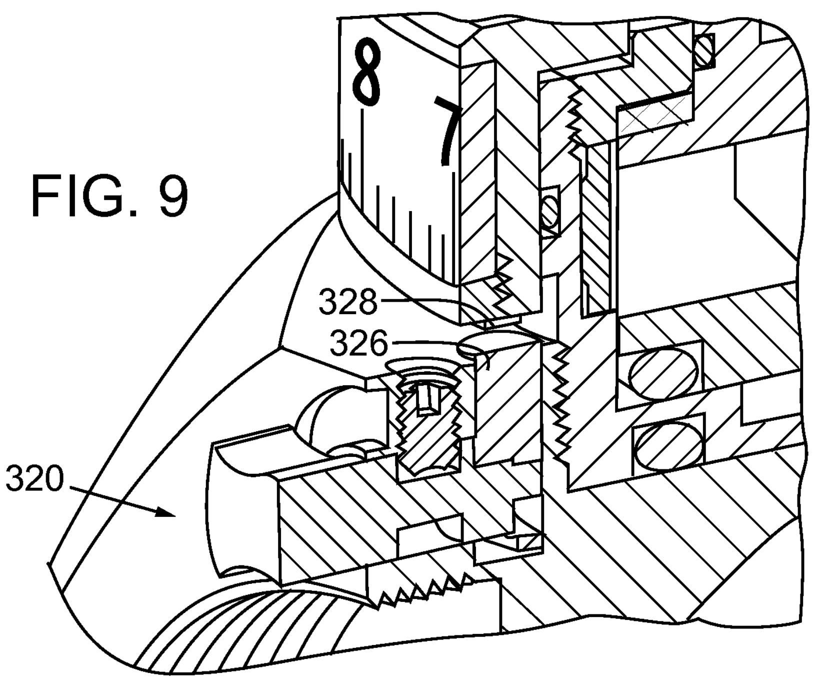

FIG. 9

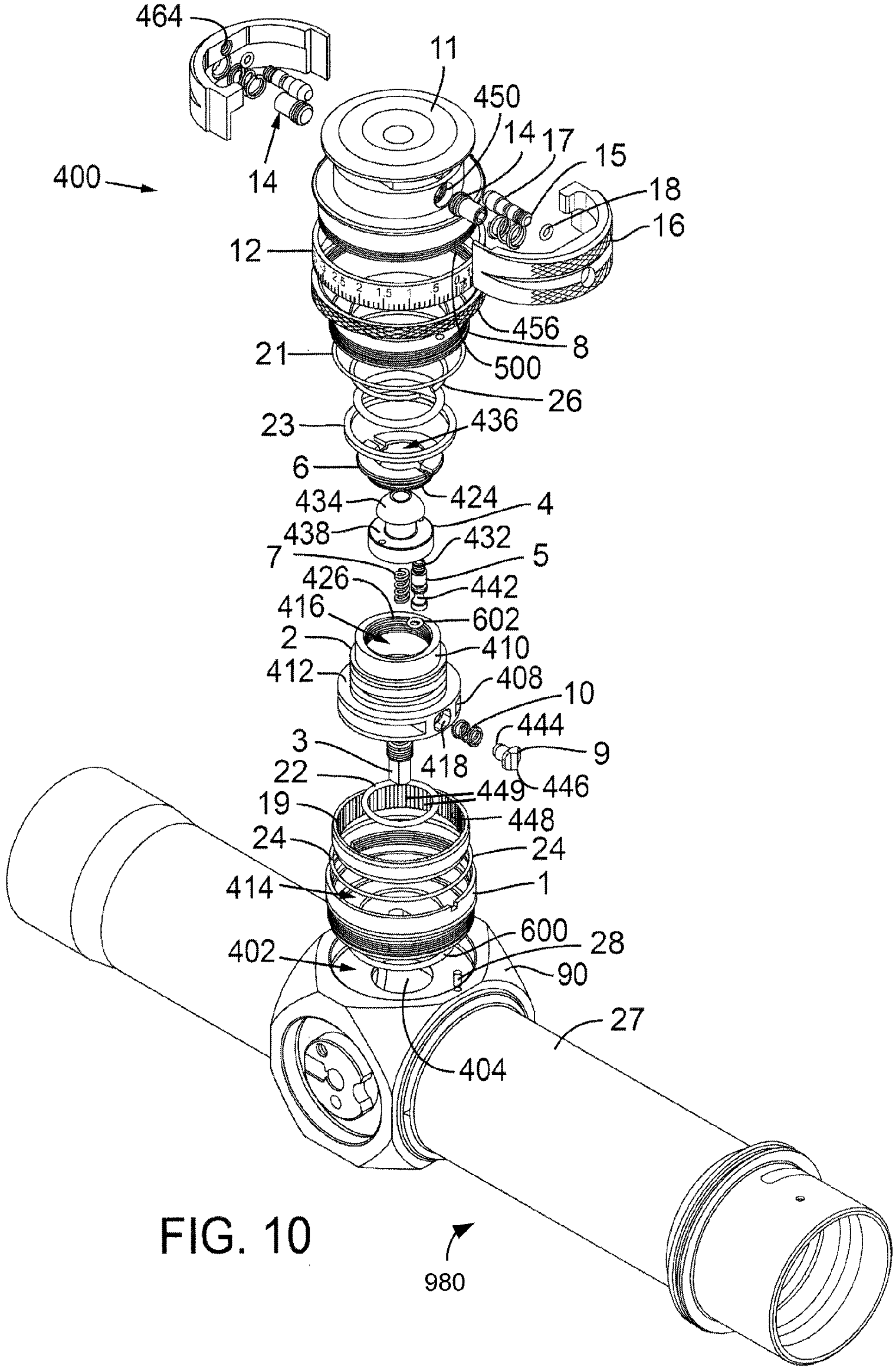
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FIG. 10

FIG. 11A

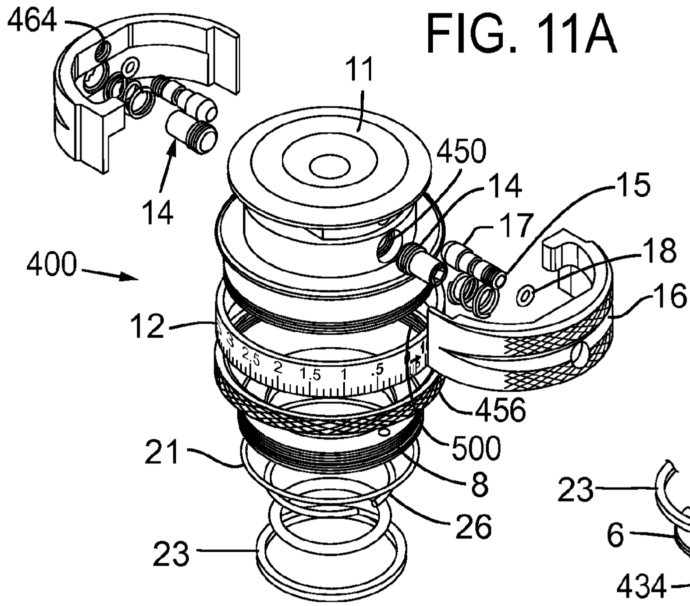
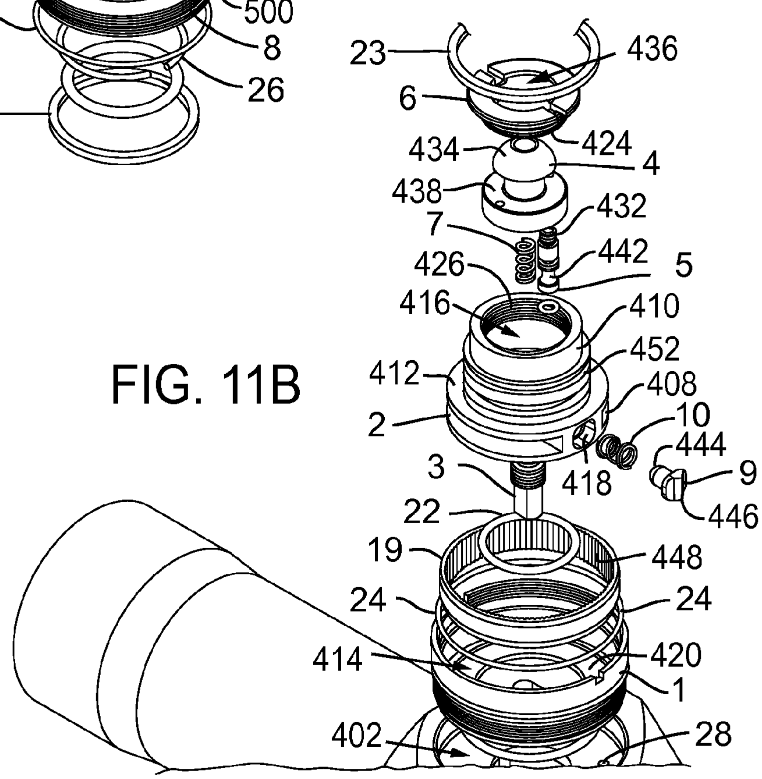


FIG. 11B



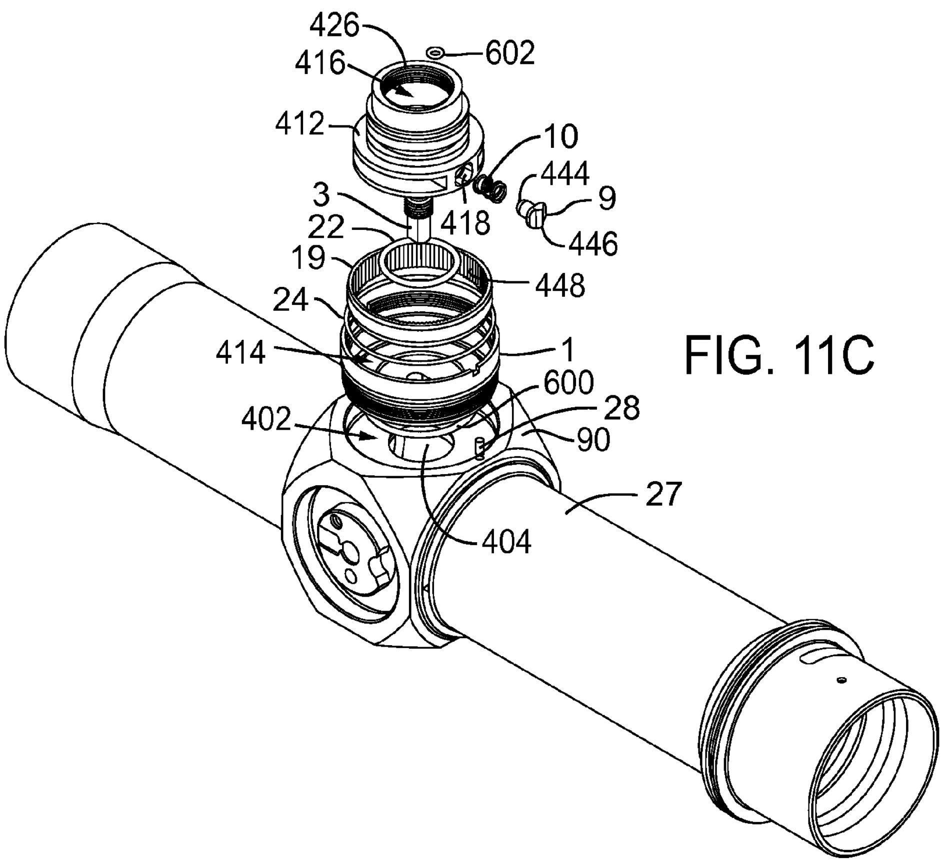

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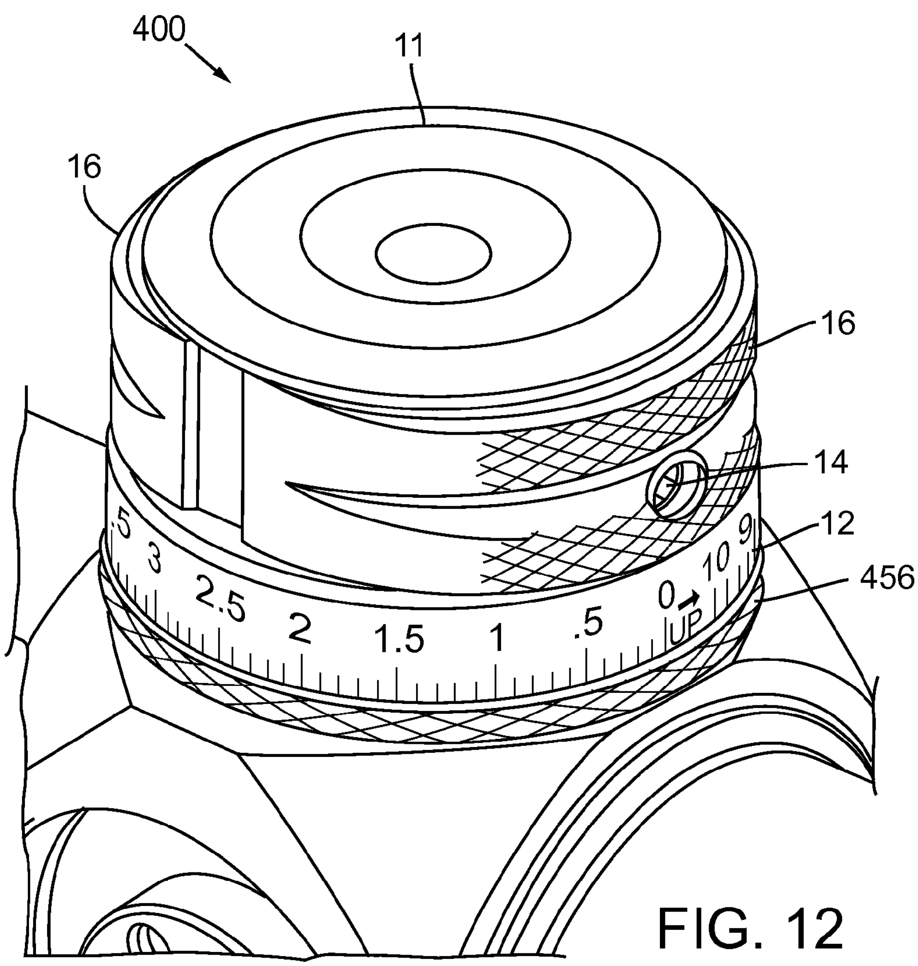
FIG. 11C



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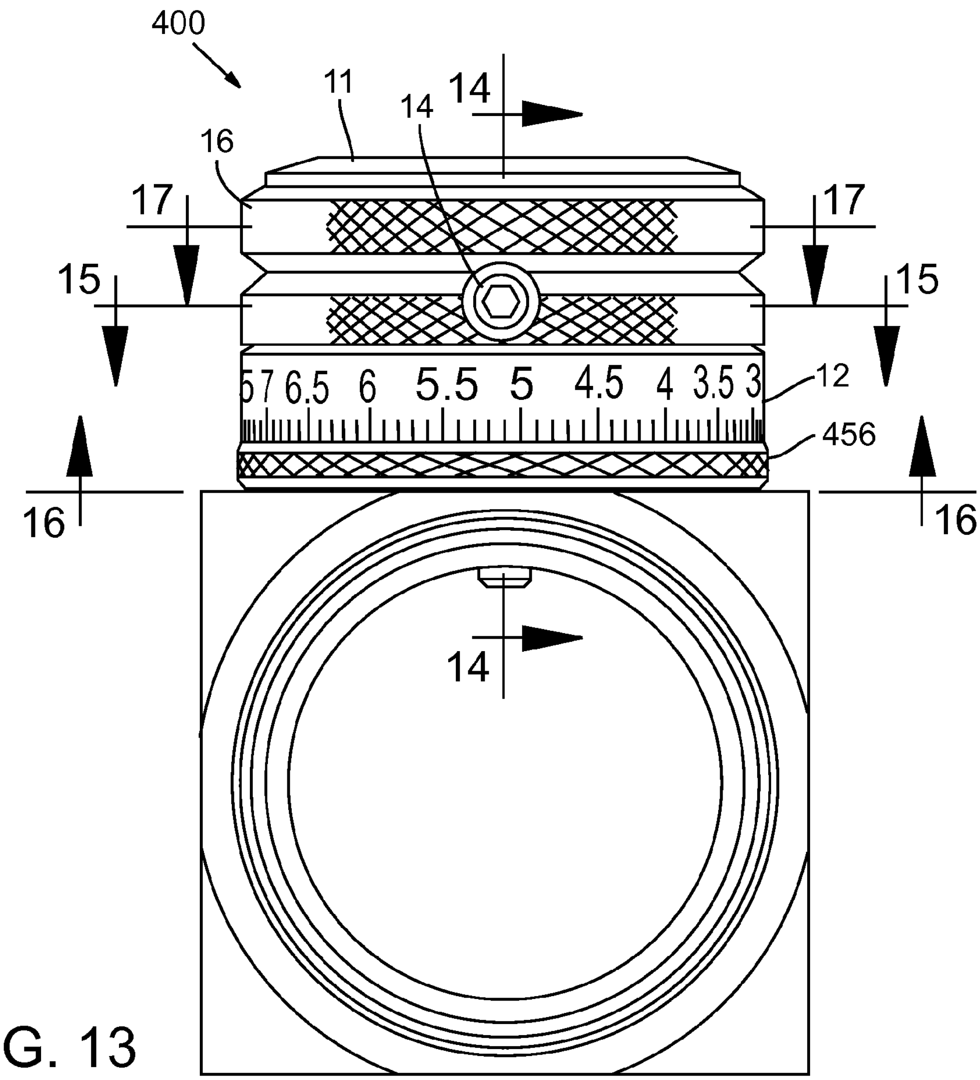

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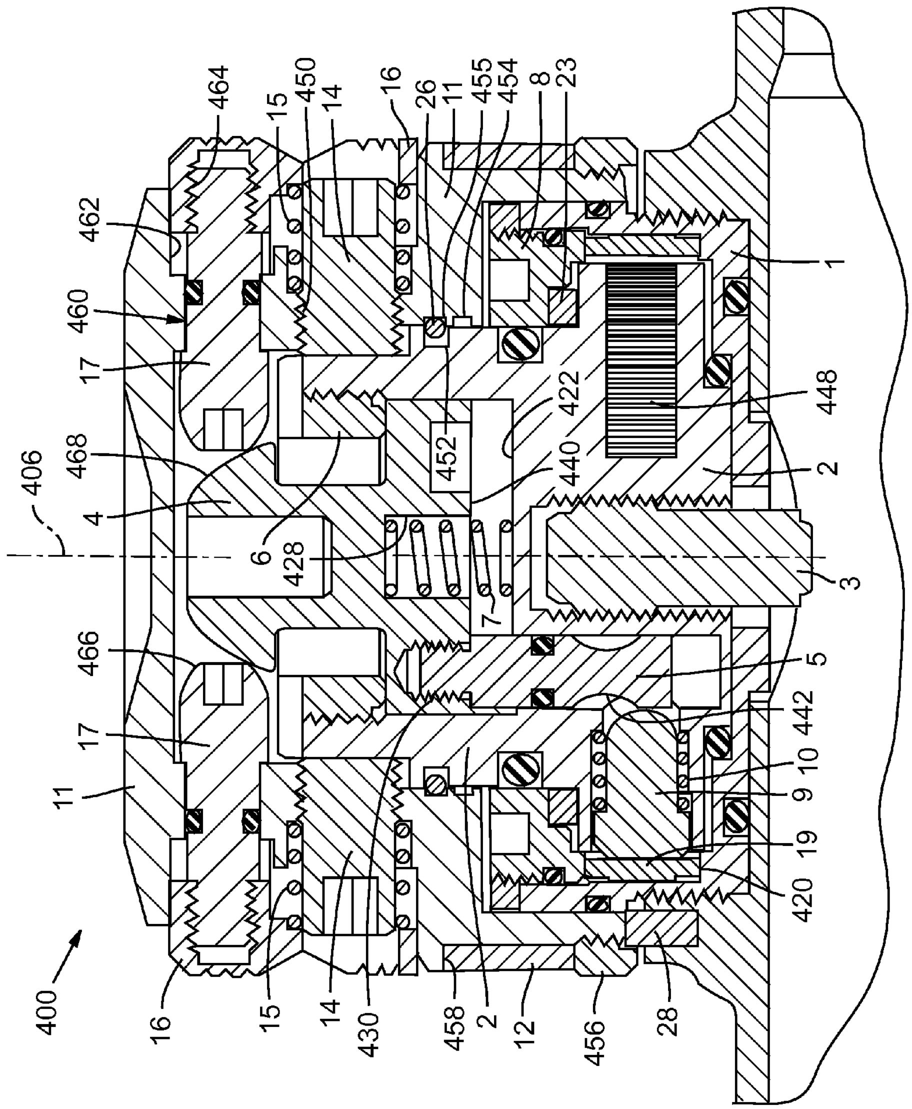
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FIG. 14A

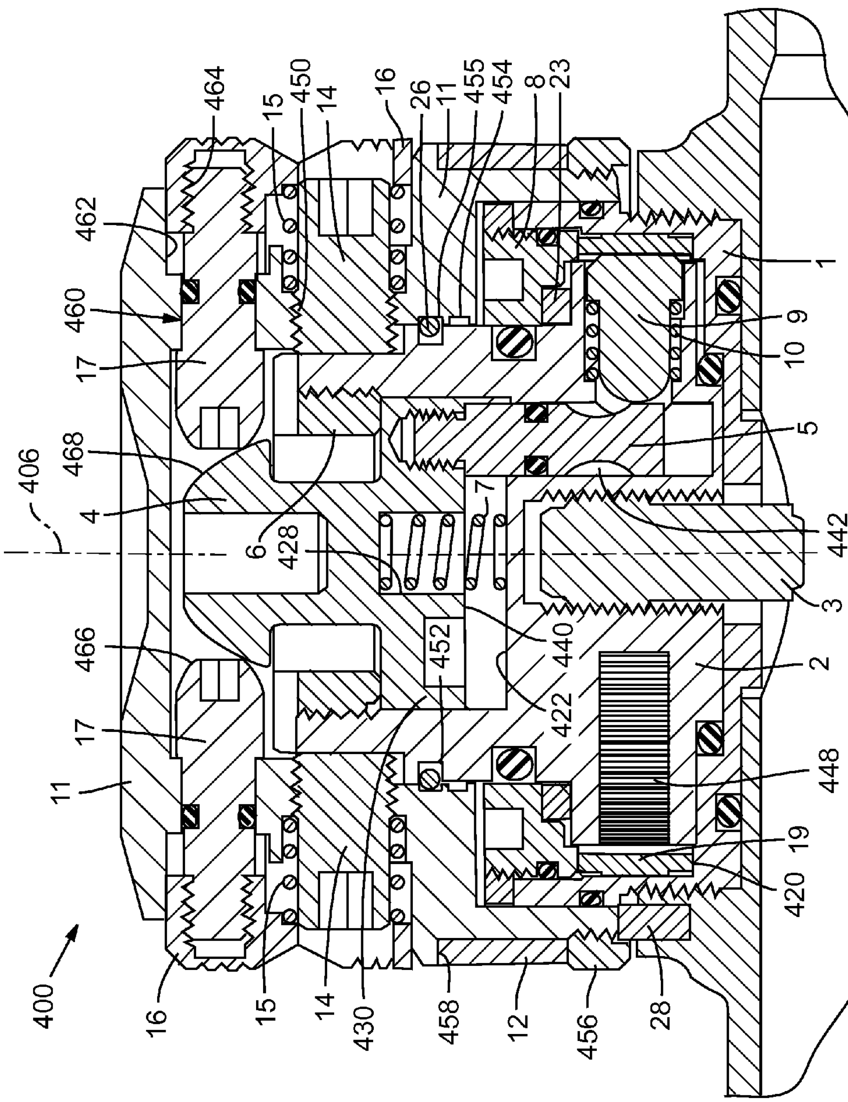
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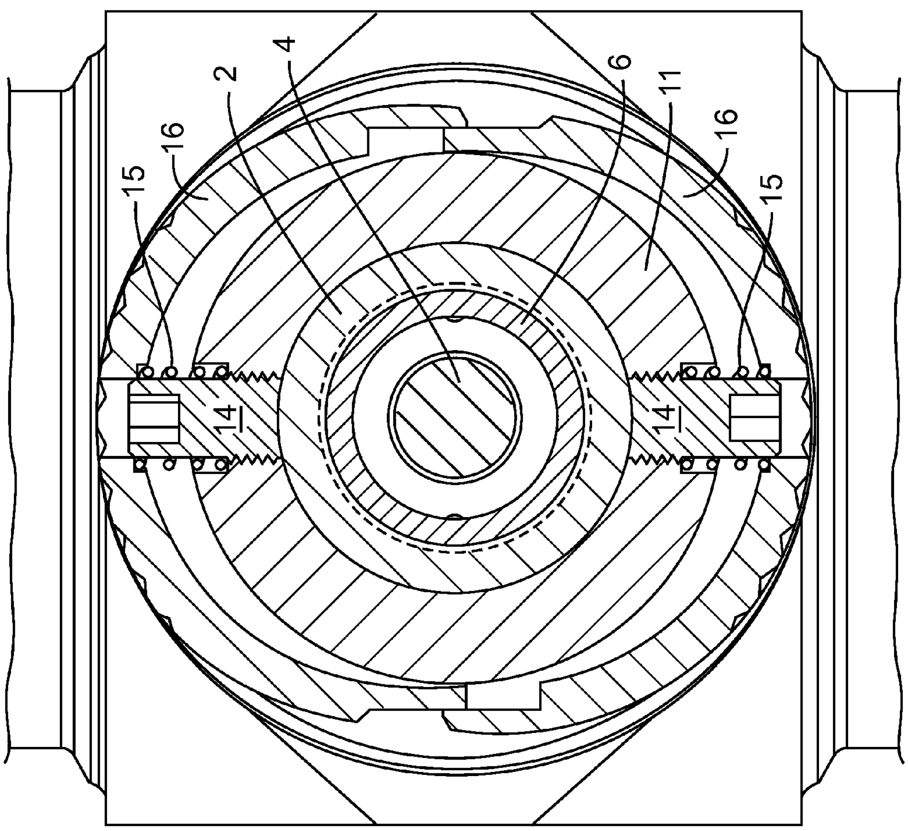
FIG. 14B



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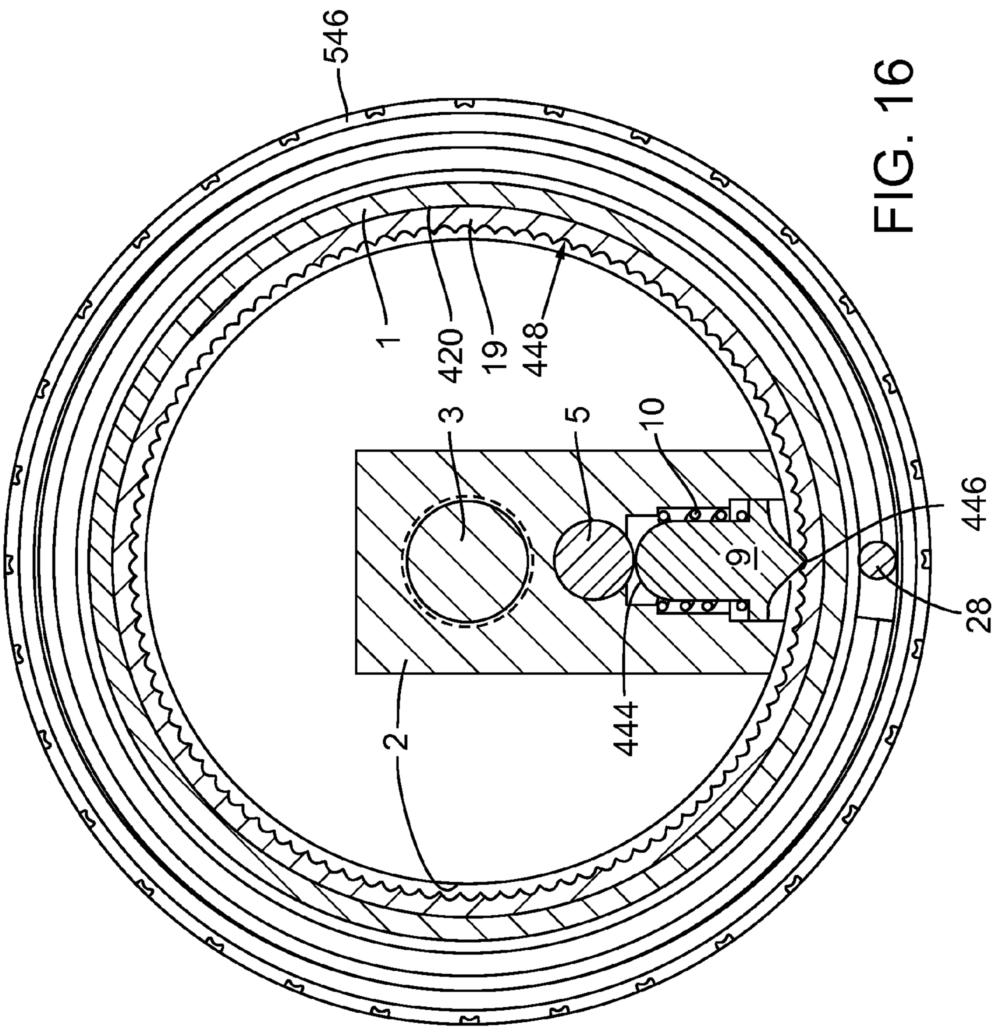

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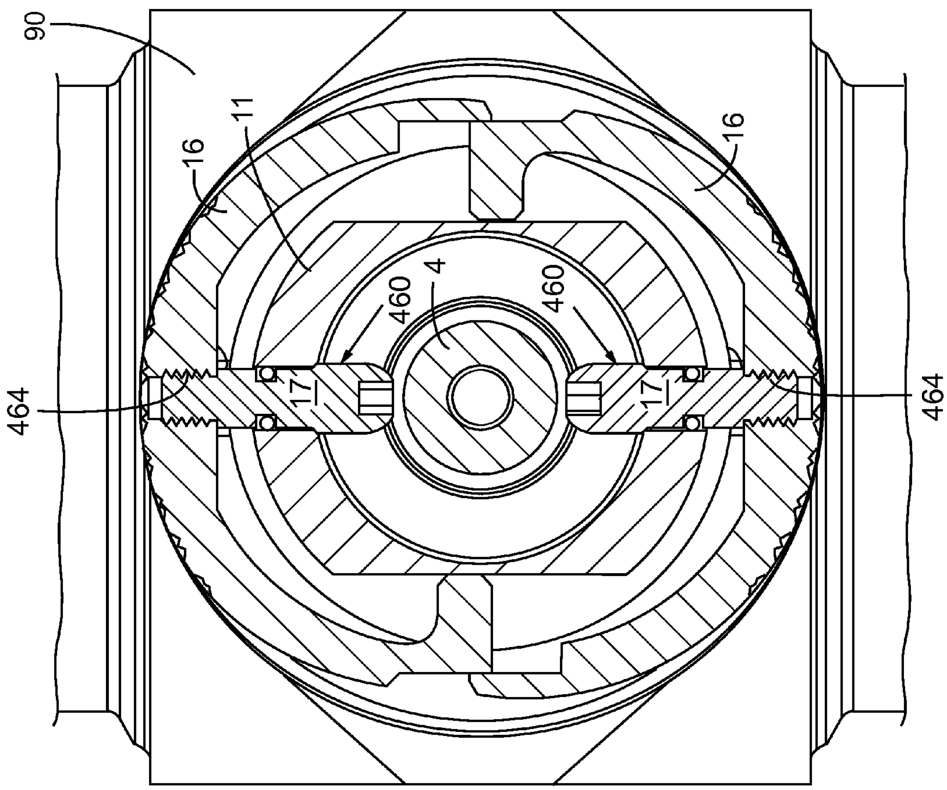

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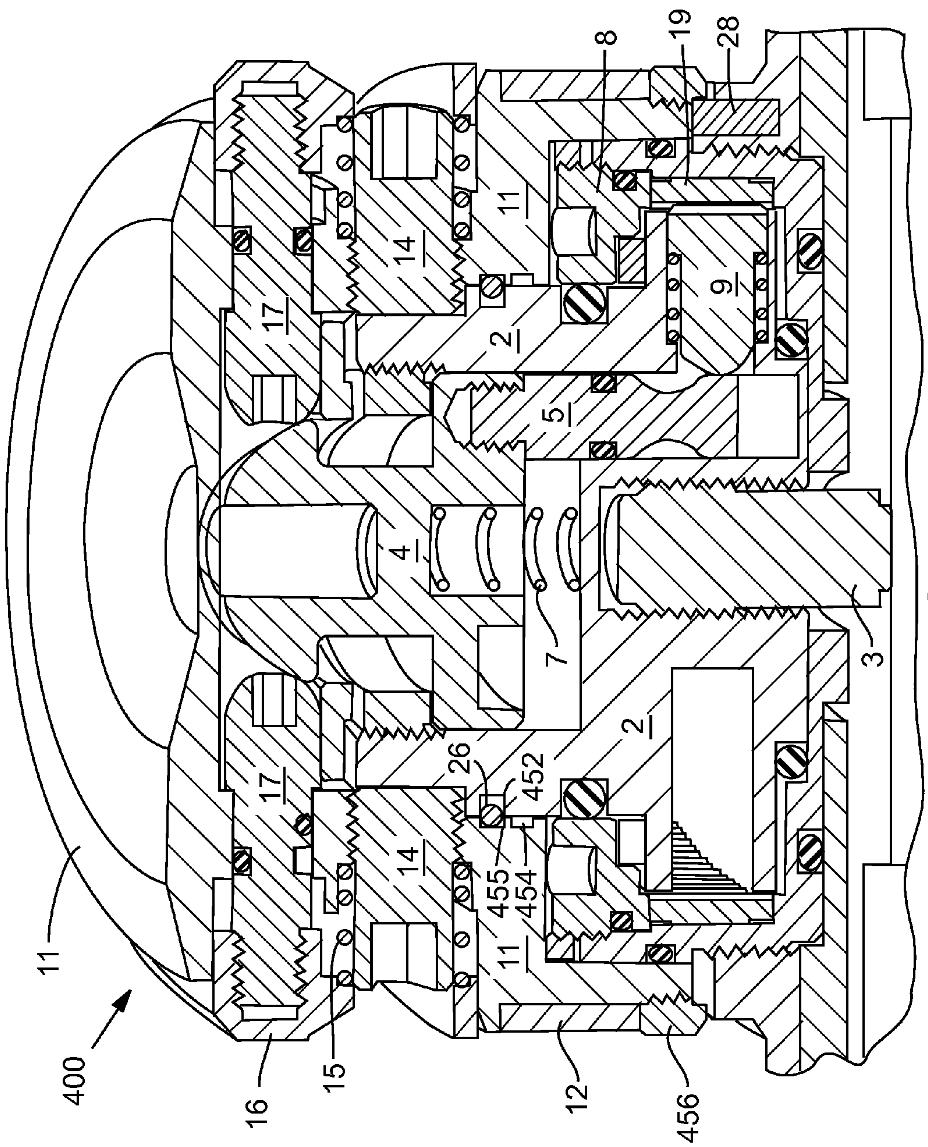

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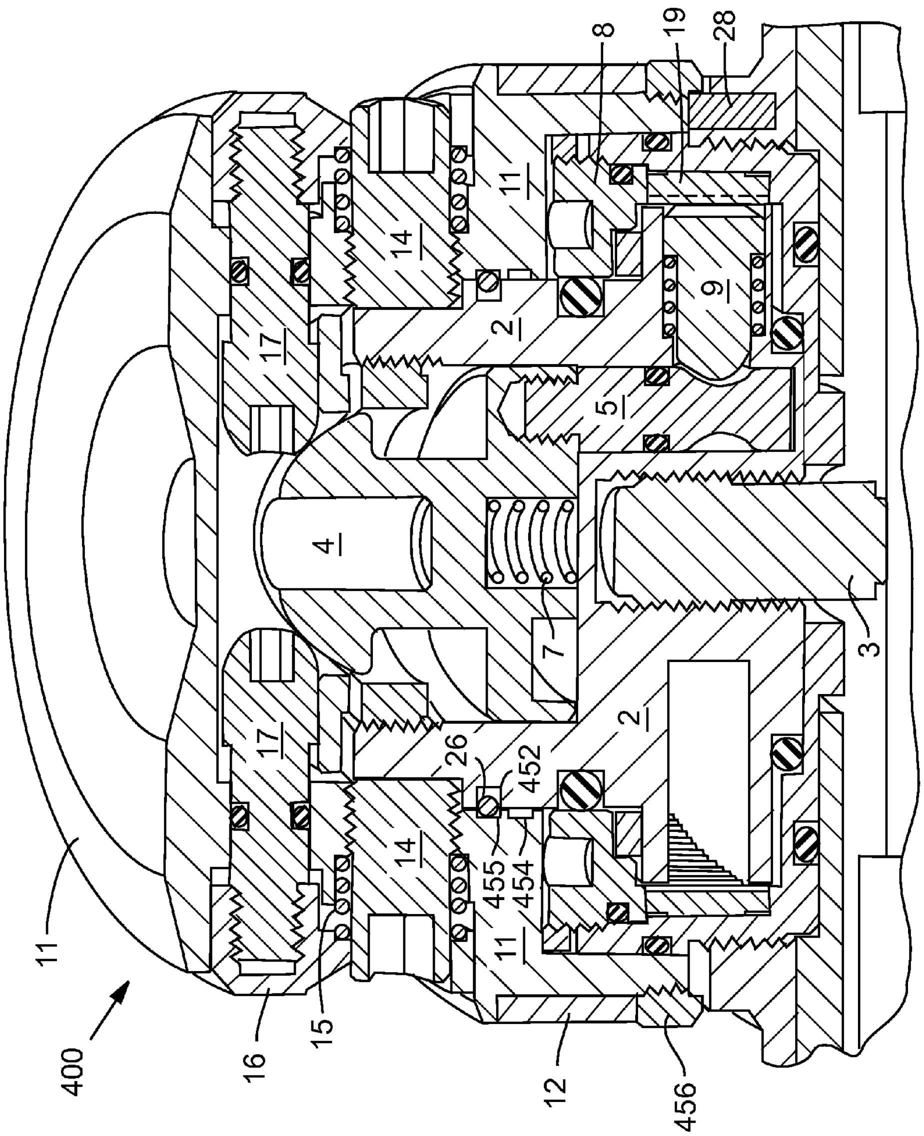

FIG. 19

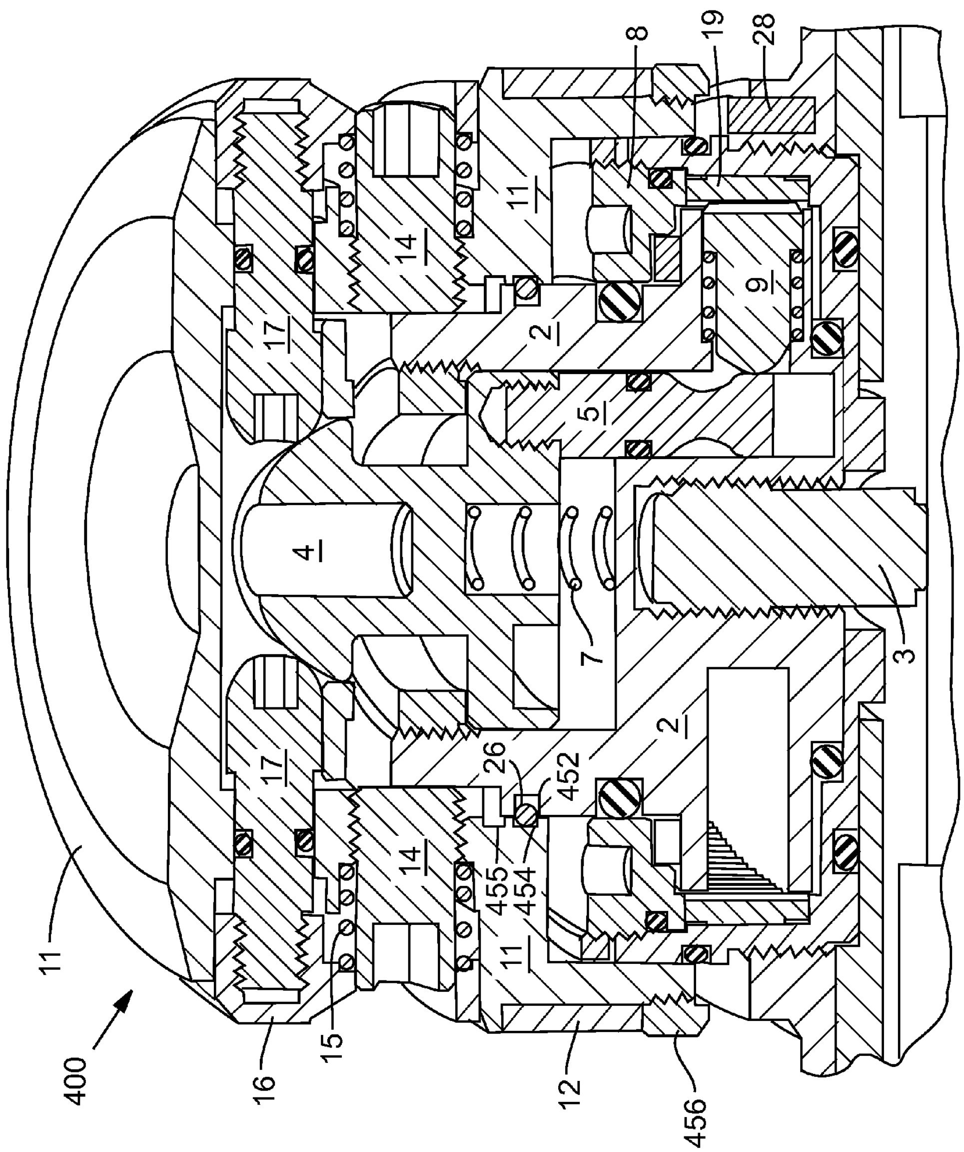

FIG. 20

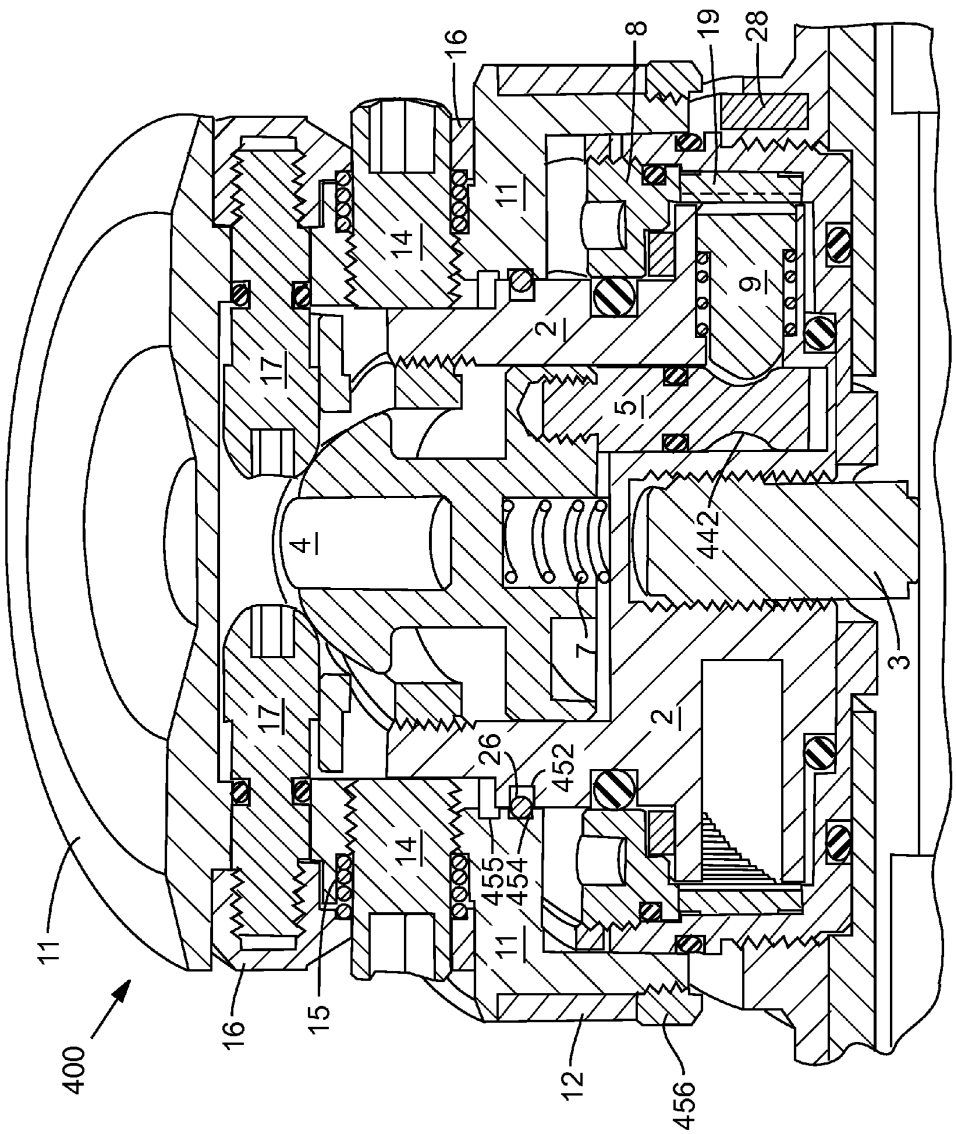

FIG. 21

AUTO-LOCKING ADJUSTMENT DEVICE

RELATED APPLICATIONS

This application claims priority under 35 U.S.C. §119(e) to U.S. Patent Application No. 61/258,190 titled "Pinch-To-Turn Auto-Locking Adjustment" filed on Nov. 4, 2009, which is incorporated by reference herein.

TECHNICAL FIELD

The field of the present disclosure relates to automatically-locking (auto-locking) devices used to make adjustments.

BACKGROUND

Rotatable adjustment knobs, or dials, are commonly used to make adjustments to an adjustable portion of a device such as an optical or electrical device. For example, rotatable dials are commonly used to adjust an elevation setting and a windage setting for a riflescope or other suitable weapon aiming device. Rotatable dials are also used to adjust other features of riflescopes, binoculars, spotting scopes, or other suitable optical device, such as parallax, focus, illumination brightness, or other suitable feature. Other examples of rotatable dials used to adjust an adjustable portion of a device include volume control dials, channel selection dials, and other suitable dials.

The present inventor has recognized that in many applications it would be advantageous for an adjustment knob or dial to automatically lock in place, thus helping ensure that the setting selected by a user remains set despite accidental forces imparted to the knob or dial, for example, during transit or other handling. Others have attempted to create knobs that lock in place. U.S. Patent Application Publication No. 2009/0205461 A1 describes one such knob that requires a user to grasp the knob while imparting a secondary motion such as pulling or pushing in order to rotate the knob.

SUMMARY

In one embodiment, an adjustment mechanism includes an actuator that moves substantially transverse to an axis of rotation to unlock the adjustment mechanism for rotation. When the actuator is released, the adjustment mechanism automatically locks in place.

Preferred adjustments include elevation or windage adjustments to a sighting device, weapon aiming device, riflescope, spotting scope, or other optical device, but disclosed auto-locking devices may be used in other mechanical or electrical devices for making a volume, channel, or station selection, or other suitable mechanical, electrical, or electronic adjustment.

The auto-locking devices described herein help prevent unintentional adjustments and otherwise help to keep an adjustment locked while a device is used, transported, or otherwise handled. For example, the auto-locking devices help prevent accidental changes to the elevation or windage adjustments when a user transports a sighting device or places the sighting device in a storage case.

The present inventor has recognized that a knob or dial manipulated by a user with a natural grasping and rotating motion, such as pinching a knob or dial between a thumb and finger and rolling the dial between the thumb and finger, without requiring additional manipulation may facilitate ease of use and may be intuitive to use.

According to one embodiment, an auto-locking dial for adjusting a portion of an optical device comprises a fixed portion non-rotatably attached to the optical device; an engagement surface non-rotatably attached to the fixed portion; and a rotatable portion rotatable about an axis of rotation and rotatably coupled to the fixed portion for rotation with respect to the engagement surface, wherein the rotatable portion includes a mechanical arrangement that rotates with the rotatable portion for driving an adjustment member. The auto-locking dial also comprises an adjustment member operatively connected to the adjustable portion of the optical device, wherein the adjustment member is operatively connected to the mechanical arrangement such that rotation of the rotatable portion about the axis of rotation causes the adjustment member to adjust the adjustable portion of the optical device; and a locking mechanism carried by the rotatable portion, the locking mechanism including a link moveable along the axis of rotation and an engagement member, wherein the engagement member contacts the engagement surface to prevent rotation of the rotatable portion with respect to the engagement surface when the link is in a lock position, and facilitates rotation of the rotatable portion with respect to the engagement surface when the link is in an unlock position. A biasing element arranged to bias the link into the lock position; and an actuator moveably coupled to the rotatable portion, wherein the actuator is configured to (a) move relative to the rotatable portion substantially transverse to the axis of rotation and (b) to engage a portion of the link to cause movement of the link along the axis of rotation toward the unlock position when an external force is applied to move the actuator are also included.

Additional aspects and advantages will be apparent from the following detailed description of preferred embodiments, which proceeds with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of an auto-locking device, according to one embodiment.

FIG. **2** is a cross-sectional view of the auto-locking device of FIG. **1** taken along line **2-2**.

FIG. **3** is an exploded view of the auto-locking device of FIG. **1**.

FIG. **4** is a cross-sectional view of the auto-locking device of FIG. **1** taken along line **4-4** illustrating the auto-locking device in a locked position.

FIG. **4**A is a cross-sectional view of an alternate embodiment of an auto-locking device.

FIG. **5** is a cross-sectional view of the auto-locking device of FIG. **1** taken along line **4-4** illustrating the auto-locking device in an unlocked position.

FIG. **6** is a cross-sectional view of the auto-locking device of FIG. **1** taken along line **6-6**.

FIG. **7** is a perspective view of an auto-locking device including an adjustment stop, according to one embodiment.

FIGS. **8** and **9** are enlarged cross-sectional views of the auto-locking device of FIG. **7** illustrating additional details of the adjustment stop.

FIG. **10** is an exploded view of an auto-locking device, according to another embodiment.

FIGS. **11**A, **11**B, and **11**C are enlarged exploded views of the auto-locking device of FIG. **10**.

FIG. **12** is a perspective view of the auto-locking device of FIG. **10**.

FIG. **13** is a side view of the auto-locking device of FIG. **10**.

FIGS. **14**A and **14**B are cross-sectional views of the auto-locking device of FIG. **10** taken along line **14-14** of FIG. **13** illustrating the auto-locking device in a locked position.

FIG. **15** is a cross-sectional view of the auto-locking device of FIG. **10** taken along line **15-15** of FIG. **13**.

FIG. **16** is a cross-sectional view of the auto-locking device of FIG. **10** taken along line **16-16** of FIG. **13**.

FIG. **17** is a cross-sectional view of the auto-locking device of FIG. **10** taken along line **17-17** of FIG. **13**.

FIG. **18** is a cross-sectional view of the auto-locking device of FIG. **10** taken along line **14-14** of FIG. **13** illustrating the auto-locking device in a locked position and adjustment stop in an engaged position.

FIG. **19** is a cross-sectional view of the auto-locking device of FIG. **10** taken along line **14-14** of FIG. **13** illustrating the auto-locking device in an unlocked position and adjustment stop in an engaged position.

FIG. **20** is a cross-sectional view of the auto-locking device of FIG. **10** taken along line **14-14** of FIG. **13** illustrating the auto-locking device in a locked position and adjustment stop in a disengaged position.

FIG. **21** is a cross-sectional view of the auto-locking device of FIG. **10** taken along line **14-14** of FIG. **13** illustrating the auto-locking device in an unlocked position and adjustment stop in a disengaged position.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

With reference to the above-listed drawings, this section describes particular embodiments and their detailed construction and operation. The embodiments described herein are set forth by way of illustration only and not limitation. Those skilled in the art will recognize in light of the teachings herein that there is a range of equivalents to the example embodiments described herein. Most notably, other embodiments are possible, variations can be made to the embodiments described herein, and there may be equivalents to the components, parts, or steps that make up the described embodiments.

For the sake of clarity and conciseness, certain aspects of components or steps of certain embodiments are presented without undue detail where such detail would be apparent to those skilled in the art in light of the teachings herein or where such detail would obfuscate an understanding of more pertinent aspects of the embodiments.

In one embodiment, an auto-locking device is actuated by squeezing or radially pinching two buttons that are rotationally coupled to a dial or knob. The two buttons, in turn, move actuator shafts inward, which causes a contact or linkage to move downward along with a lock pin (which is coupled to the linkage). The lock pin includes a circumferential groove into which a portion of a clicker can enter. The downward motion of the lock pin causes the circumferential groove of the lock pin to align with the clicker, which allows the clicker (and a spindle to which the clicker is rotationally coupled) to freely rotate against a stationary lock ring, thereby allowing a threaded plunger or screw to move up or down relative to a spindle base. The auto-locking device may include an indicator, which allows the user to monitor the extent of rotation of the knob, and may permit a user to customize a knob to a particular device by replacing the indicator ring. The pinch-and-turn motion preferably allows the user to unlock the knob and make an adjustment with relative ease using a natural grasping motion, and preferably allows the user to avoid performing multiple separate motions (e.g., grasp, pull-up and turn or grasp, push-down and turn) to make an adjustment.

FIGS. **1-5** illustrate various views of an auto-locking device **100**, according to another embodiment. FIG. **4**A illustrates another embodiment. As shown in FIG. **3**, the auto-locking device **100** is mounted to a main tube **102** of an optical device **990** depicted as a riflescope. While the following description is made with reference to a riflescope, the auto-locking device **100** may be used with other devices, including optical devices such as binoculars, spotting scopes or other sighting devices, weapon aiming devices, microscopes, or other suitable optical devices. In addition, although the following description is made with reference to a single auto-locking device **100**, the riflescope may include additional auto-locking devices **100** as adjustment mechanisms, such as a horizontal adjustment mechanism for a windage adjustment and a vertical adjustment mechanism for an elevation adjustment. Further, although the auto-locking device **100** may be used to adjust elevation and windage, the auto-locking device **100** may be also be used for other adjustments, such as focus, magnification, illumination control, or other suitable adjustment. Still further, the auto-locking device **100** may be used with other suitable devices, such as a knob or adjustor for a microscope or telescope, a machine subjected to relatively large amounts of vibration, vehicles such as aircraft and automobiles and equipment located therein, or any other suitable device that is adjusted in whole or part by rotating an adjustment device bearing a locking mechanism.

Within the main tube **102** of the riflescope, an inner tube **103** (FIGS. **4** and **5**) bearing a reticle or lens assembly may be movably mounted perpendicular to a longitudinal tube axis, for example, by a ball-and-socket joint between one end of the inner tube **103** and the main tube **102**. A seat **101** is secured to a main tube **102**. The seat **101** includes a bore **104** sized to receive the auto-locking device **100**. The bore **104** preferably includes threads **106** formed on an interior wall or shoulder of the bore **104** that mate with threads **108** on a spindle base **110**. In some embodiments, a seat, such as seat **101**, constitutes a fixed portion of an auto-locking device. In other embodiments, a base, such as spindle base **110**, constitutes a fixed portion of an auto-locking device. In other embodiments, a seat and a spindle base together constitute a fixed portion of an auto-locking device. In yet other embodiments, a fixed portion of an auto-locking device may be formed as part of a device.

An aperture **105** is formed at the base of the bore **104** and is sized to receive a threaded plunger or screw **120**. The plunger **120** interacts with one end of the inner tube **103** and is constrained from rotating about an axis of rotation **130** (FIG. **4**) so that rotation of a spindle **140** (into which the plunger **120** is threaded) is translated into linear motion of the plunger **120** along the axis **130**, thereby adjusting a position of the reticle or lens assembly (e.g., the reticle is shifted perpendicular to the tube axis). In other embodiments, plunger **120** may include a squared-off portion that interacts with a squared-off opening in main tube **102**, spindle base **110**, or seat **101** to prevent plunger **120** from rotating about the axis **130**. In other embodiments a different mechanical arrangement may be used to move an adjustment member, such as plunger **120**, for example, a crown gear arrangement or other suitable mechanism, for example, as is well known in the riflescope arts.

There are many other possible configurations for the main tube **102** and the inner tube **103** and for the optics or reticle, such as the riflescopes described in U.S. Pat. Nos. 6,279,259,

6,351,907, 6,519,890, and 6,691,447, all of which are hereby incorporated by reference in their entireties.

Referring now to FIGS. **3**, **4**, and **5**, one arrangement for constraining the plunger **120** from rotating about axis **130** includes coupling the plunger **120** to the inner tube **103**. For example, a rectangular hole in the inner tube **103** may be aligned with the center of the aperture **105** and the rectangular hole may be sized to receive a keyed end **122** of the plunger **120** to prevent the adjustment plunger **120** from rotating about the axis of rotation **130**. The plunger **120** may be non-rotationally coupled to the inner tube **103** in other ways, such as threaded into the inner tube **103**, welded to the inner tube **103**, or otherwise secured to the inner tube **103** (e.g., via an epoxy). The plunger **120** includes threads **124** at an end of the plunger **120** opposite the keyed end **122**. The threads **124** are preferably sized to mesh with interior threads **141** of the spindle **140** so that the plunger **120** can be threaded into the spindle **140**. Thus, rotation of the spindle **140** about the axis of rotation **130** is translated into linear motion of the plunger **120** along the axis of rotation **130**, thereby adjusting a position of the inner tube **103** (and thus the reticle or optics therein). The pitch, fineness, or other attribute of threads **124** and **141** may be altered depending on the amount of adjustment desired for a corresponding amount of rotation of spindle **140**. Threads **124** and **141** may not be traditional threads, but may include opposing ramped surfaces or other suitable structure for changing rotational movement of spindle **140** into linear movement of plunger **120**.

The spindle **140** includes a lower base portion **142** and an upper neck portion **144**, which preferably is smaller in diameter than the lower base portion **142**. The lower base portion **142** of the spindle **140** is sandwiched between a flanged lock nut **150** and the spindle base **110**. Thus, the spindle **140** is rotatable about the axis of rotation **130** but is constrained from traveling along the axis of rotation **130** by the flanged lock nut **150** (which is threaded into spindle base **110**) and the spindle base **110** (which is threaded into the bore **104** of the main tube **102**). A washer **160** may be sandwiched between a shoulder **143** of the spindle **140** and the flanged lock nut **150** to facilitate rotation of the spindle **140** within a cavity **111** of the spindle base **110**. The washer **160** may be made from any suitable wear-resistant low friction material, such as nylon, polytetrafluorethylene (PTFE) polymer (e.g., Teflon®), or other suitable material. The upper neck portion **144** of the spindle **140** extends through a central aperture **152** of the flanged lock nut **150** and includes a cavity **145** (FIG. **4**) into which components of a locking mechanism **153** including a contact or linkage **170** and a locking pin **220** nest. The spindle **140** also includes a bore **146** into which a clicker or wedge pin **180** extends. Additional details of the linkage **170** and the wedge pin **180** will be described in more detail below.

The spindle base **110** is threaded onto the main tube **102** so that the spindle base **110** does not rotate relative to the seat **101** as the spindle **140** rotates about the axis of rotation **130**. A lock ring **190** is interposed between a shoulder **112** of the spindle base **110** and the flanged lock nut **150** and is preferably constrained from rotating about the axis of rotation **130**. For example, as the outer threads **154** on the flanged lock nut **150** are threaded into the interior threads **113** of the spindle base **110**, the lock ring **190** is pinched between the shoulder **112** of the spindle base **110** and the flanged lock nut **150** to thereby prevent the lock ring **190** from rotating about the axis **130**. The lock ring **190** may be prevented from rotating about the axis **130** in other ways, such as being secured to the spindle base **110** (e.g., via a weld or epoxy). In addition, a pin (not shown) may extend between the spindle base **110** and the lock ring **190** to prevent rotation relative to each other. Thus, the seat **101**, the lock ring **190**, and the flanged lock nut **150** are anchored to the main tube **102** and are prevented from rotating about the axis **130** when the auto-locking device **100** is in a locked or unlocked position.

In a preferred arrangement, lock ring **190** includes an engagement surface **192** that faces spindle **140**. The engagement surface **192** includes regularly spaced apart features, such as detents **193**. The detents **193** or other engagement features may include splines or a series of evenly spaced grooves, indentations, apertures, or other suitable features that may be included on or formed in the engagement surface **192**. Regularly spaced apart features preferably include ramped surfaces that facilitate a clicker or wedge pin **180** transitioning from one engagement feature to another engagement feature when spindle **140** is rotated about axis **130** as described in further detail below. Lock ring **190** therefore preferably provides an engagement surface suitable for holding a locking mechanism in place when the locking mechanism is in a locked position and suitable for providing audible clicks, tactile clicks, or both when the locking mechanism is in an unlocked position. In other arrangements, a lock ring, such as lock ring **190**, may provide only an engagement surface suitable for holding a locking mechanism in place when the locking mechanism is in a locked position.

The linkage **170** is nested in a portion of the cavity **145** between a bottom surface **147** of the cavity **145** and a retaining nut **200**. The retaining nut **200** is provided with outer threads **202** that mate with inner threads **148** of the neck **144** of the spindle **140**. The retaining nut **200** limits the travel of the linkage **170** along the axis **130**. The linkage **170** includes a bore **172** sized to receive a biasing element, such as spring **210**, which is provided to bias the linkage **170** toward a locked position, for example upward (e.g., away from the bottom surface **147** of the cavity **145**). In other embodiments (not shown), a locked position of linkage **170** may be proximate the bottom surface **147** and the biasing element may bias linkage **170** toward the bottom surface **147**. The linkage **170** also includes an offset bore **174**, which includes interior threads sized to mate with a threaded portion **222** of a locking pin **220**. A protrusion **176** of the linkage **170** extends through an aperture **204** of the retaining nut **200** for interaction with a pair of actuator shafts **230** and **232**. Thus, the linkage **170** is configured for movement between a first (locked) position (FIG. **4**) and a second (unlocked) position (FIG. **5**). The locking pin **220** travels along with the linkage **170** as the linkage **170** moves between the first and second positions along the axis **130**.

The locking pin **220** includes a circumferential groove **224** into which a butt **182** of the wedge pin **180** can enter. When the locking pin **220** is positioned as shown in FIG. **4**, the locking pin **220** urges an engagement portion of wedge pin **180**, such as wedge portion **184**, to engage the engagement surface **192**, for example, by interacting with corrugations, grooves, or splines formed in the engagement surface **192** of the lock ring **190**. Because butt **182** of the wedge pin **180** is misaligned from the circumferential groove **224** of locking pin **220** when in the locked position, the interaction of wedge pin **180** with the engagement surface **192** and the interaction of wedge pin **180** with spindle **140** inhibits spindle **140** from rotating with respect to the lock ring **190**.

When the locking mechanism, including locking pin **220**, is positioned as shown in FIG. **5** in the unlocked position, the circumferential groove **224** is aligned with the wedge pin **180**. As the spindle **140** rotates about the axis of rotation **130**, the wedge portion **184** of the wedge pin **180** is permitted to move with respect to the engagement surface **192**, for example, because the butt **182** of the wedge pin **180** can enter the

circumferential groove **224** against the bias of spring **186**. The interaction of wedge pin **180** with the engagement surface **192** and the interaction of wedge pin **180** with circumferential groove **224** thus facilitates spindle **140** to rotate with respect to the lock ring **190**. In preferred arrangements, the wedge pin **180** provides tactile feedback to the user as the wedge pin **180** engages and disengages regularly spaced apart features formed on or in the engagement surface **192**, in other words, the user can determine an angular rotation of the spindle **140** by counting the number of clicks. In other embodiments, an engagement member, such as wedge pin **180**, facilitates rotation of a rotatable portion, such as spindle **140**, by not engaging an engagement surface when in the unlock position, or by selectively or intermittently engaging an engagement surface, for example, by moving out of and into spaced apart features formed in or on the engagement surface.

In the embodiment illustrated in FIGS. **1**, **2**, **3**, **4**, and **5**, the assemblage of linkage **170** and locking pin **220** comprise a link that forms part of the locking mechanism. The link of FIGS. **1**, **2**, **3**, **4**, and **5** interacts with wedge pin **180** to further form part of the locking mechanism. In other embodiments the locking mechanism includes a link comprising a linkage, such as linkage **170**, a locking pin, such as locking pin **220**, and a stopping element, such as wedge pin **180**. In other embodiments, the locking mechanism includes a link comprising a linkage, such as linkage **170**, a locking pin, such as locking pin **220**, a stopping element, such as wedge pin **180**, and an engagement surface **192**. In yet other embodiments, a link may include a linkage and a locking pin that are formed as one item.

A knob **250** is installed over the spindle **140** and the spindle base **110**. In some embodiments, a rotatable portion of a dial constitutes a spindle, such as spindle **140**, and a knob, such as knob **250**. In other embodiments a rotatable portion of a dial constitutes either a spindle or a knob. The knob **250** includes a set of opposed threaded bores **251** sized to receive a pair of threaded set screws **260** and **262**. Any number of set screws may be provided around the axis **130**. As illustrated in FIG. **6**, the set screws **260** and **262** rotationally couple the knob **250** to the neck **144** of the spindle **140**. A tool, such as a hex key, can be used to tighten the set screws **260** and **262** such that the screws **260** and **262** bear against the neck **144** of the spindle **140**. Similarly, the tool can be used to loosen the set screws **260** and **262** so that knob **250** can be rotated relative to spindle **140** about axis **130** to adjust a calibration or "zero" setting of the device **100**, as described in further detail below. In other embodiments, knob **250** may be sized and dimensioned to snap fit or press fit over spindle **140**.

An indicator **270** slips over a base of the knob **250** and is typically marked with a scale around its circumference that allows the user to take a reading with respect to an index mark on the seat **101**. The indicator ring **270** preferably includes a notch **272** that mates with a boss **252** on the knob **250** so that the indicator ring **270** can be aligned with the knob **250**. As a lock ring **280** is threaded onto the base of the knob **250**, the indicator ring **270** is sandwiched between a shoulder **253** of the knob **250** and the lock ring **280**. The indicator ring **270** may be replaced with another similar indicator ring, but bearing a different set of markings to customize an auto-locking dial for a particular device. For example, when an auto-locking dial is used to adjust a setting of a riflescope, such as elevation, an indicator ring **270** that is specific to the caliber of the rifle to which the riflescope is mounted may be included on the knob **250**. Such a caliber-specific indicator ring **270** preferably includes markings appropriately spaced to compensate for bullet drop for the caliber at particular distances. With such an indicator ring **270** attached to knob **250**, after a rifle is zeroed at a known distance a shooter merely turns the knob **250** to a different distance indicated by ring **270** to hit a target at that distance using the specific caliber of the rifle. In other embodiments, indication marks may be made directly on a knob, such as knob **250**.

A set of actuator shafts **230** and **232** are inserted into a set of opposed bores **254** formed in the knob **250**. The actuator shafts **230** and **232** include a threaded portion **233** that threads into a threaded bore **243** of buttons **240** and **242** (which are shown having a C-shape). In the illustrated embodiment, actuator shafts are inserted into cavity **256** of knob **250** such that shoulders **234** prevent actuator shafts **230** and **232** from passing completely through bores **254**. Connecting actuator shafts **230** and **232** to buttons **240** and **242**, respectively, help hold buttons **240** and **242** in place on knob **250**. In other embodiments, actuator shafts, such as actuator shafts **230** and **232**, may be formed as part of buttons, such as buttons **240** and **242**. A set of biasing elements, such as springs **290** and **292**, are optionally provided to bias the buttons **240** and **242** toward an extended position (as shown in FIG. **4**). The springs **290** and **292** may be positioned in bores formed in the knob **250**. In some embodiments, spring **210** acting via linkage **270** may impart sufficient force on actuator shafts **230** and **232** to bias the buttons **240** and **242** toward an extended position.

The actuator shafts **230** and **232** are provided with a sloped surface **231**, which may include a frustoconical shaped portion that interacts with a sloped portion **171**, such as a hemispherical shaped portion of the linkage **170**. The sloped surface of actuator shafts **230** and **232** and the sloped portion of linkage **170** may include flat or relatively flat surfaces, curved surfaces, or other suitable shapes or contours. In other embodiments, sloped surfaces **231** and **171** are configured and arranged to pull linkage **170** upwardly away from surface **147** when buttons **240** and **242** move toward the axis **130**. In one such embodiment a circumferential groove similar to circumferential groove **224** may be included in protrusion **176** such that the circumferential groove is located below actuator shafts **230** and **232**. Circumferential groove **224** may be located underneath wedge pin **180** instead of over wedge pin **180** as illustrated in FIGS. **4** and **5**. Thus, when actuator shafts **230** and **232** move toward each other, protrusion **176** moves upward as does locking pin **220**.

As shown in FIG. **2**, the actuator shafts **230** and **232** may be offset from each other. In addition, the actuator shafts **230** and **232** may be in-line with each other (as shown in FIG. **17**), which may help avoid play between the actuator shafts **230** and **232** and the linkage **170**. The buttons **240** and **242** can be spaced apart (as shown in FIG. **2**) or can slide over each other (as shown in FIG. **10**). Alternatively, a single actuator may be used. In some embodiments, an actuator includes both a button, such as button **240**, and an actuator shaft, such as actuator shaft **230**. In other embodiments, an actuator includes an actuator shaft.

The operation of the auto-locking device **100** will now be described with reference to FIG. **4** (illustrating a locked configuration) and FIG. **5** (illustrating an unlocked configuration). The user actuates or unlocks the auto-locking device **100** by grasping and squeezing or radially pinching the buttons **240** and **242** between a thumb and finger. Such grasping and squeezing causes the actuator to move toward the axis **130**, for example, actuator shafts **230** and **232** move toward the linkage **170** against the bias of the springs **290** and **292** as illustrated in FIG. **5**. In one arrangement, when buttons **240** and **242** are squeezed, the linkage **170** moves to an unlocked position after an outer surface **244** of each button **240** and **242** moves toward the axis of rotation **130** such that the outer

surface **244** is located substantially even with, or inward of, an outer surface **255**A, **255**B, or both of knob **250**, for example, as illustrated in FIG. **5**.

The sloped surfaces **231** of the actuator shafts **230** and **232** interact with the sloped portion **171** of the linkage **170** to cause the linkage **170** to move along with the locking pin **220** (which is coupled to the linkage **170**) against the bias of spring **210** to an unlock position. In other words, the interaction between the actuator and the linkage **170** is configured to convert radial motion of the actuator shafts **230** and **232** into axial motion of the locking pin **220**. After the linkage **170** has moved to an unlocked position, for example adjacent or abutting the bottom surface **147** of the cavity **145**, the circumferential groove **224** of the locking pin **220** is aligned with the wedge pin **180**. As previously noted, the wedge pin **180** is biased by the spring **186** to engage the engagement surface **192** of the lock ring **190**. But, when the circumferential groove **224** is aligned with the wedge pin **180**, the butt **182** of the wedge pin **180** can enter the circumferential groove **224** thus permitting wedge pin **180** to engage and disengage the engagement surface **192** of the lock ring **190** as the user rotates the knob **250** the spindle **140**, and wedge pin **180** about the axis **130**. Rotation of the spindle **140** causes the plunger **120** to move along the axis **130** thereby adjusting a position of an adjustable portion of a device, such as the inner tube **103**, for example. In other arrangements, an engagement member, such as wedge pin **180**, may be coupled to a link, such as linkage **170** and locking pin **220**, for movement along axis **130**. Accordingly, an engagement surface is preferably positioned and configured to interferingly interact with the engagement member when the link is in a lock position and to facilitate rotation of a rotatable portion when the link is in an unlock position.

When the user releases the buttons **240** and **242**, the springs **290** and **292** cause the buttons **240** and **242** and the actuator shafts **230** and **232** to move to the position illustrated in FIG. **4**. Once the actuator shafts **230** and **232** are out of the way, the spring **210** causes the linkage **170** and the locking pin **220** to move upward toward the position shown in FIG. **4**. In other embodiments, the spring **210** is sufficiently strong to move the linkage **170** and the buttons **240** and **242** to the positions shown in FIG. **4** without springs **290** and **292**. Because the circumferential groove **224** is no longer aligned with the wedge pin **180**, the locking pin **220** causes the wedge shaped portion **184** of the wedge pin **180** to engage at least one of the regularly spaced apart features of the engagement surface **192** of the lock ring **190**. Because the lock ring **190** is anchored to the main tube **102**, the wedge pin **180** (which is coupled to the spindle **140** for rotation therewith) prevents the spindle **140**, and thus the knob **250**, from rotating about the axis **130** (i.e., the knob **250** is automatically locked once an external force is removed from the actuator, such as buttons **240** and **242** and actuator shafts **230** and **232**).

Any number of optional seals, such as O-rings, may be provided to keep out contamination. For example, as illustrated in FIG. **3** an O-ring **300** may be provided between the seat **101** and the spindle base **110**, an O-ring **302** may be provided between the spindle base **110** and the knob **250**, an O-ring **304** may be provided between the spindle **140** and the spindle base **110**, an O-ring **306** may be provided between the spindle **140** and the flanged retaining nut **150**, and an O-ring **308** may be provided between the spindle retaining nut **200** and the spindle **140**. In addition, O-rings **310** may be provided between the actuator shafts **230** and **232** and the knob **250**. Optionally, thread lock materials or waterproofing materials, such as LocTite® or Teflon® tape may be included at any or all of the threaded interfaces (but not between the plunger **120** and spindle **140**).

In some embodiments, a knob, such as knob **250**, or a spindle, such as spindle **240**, may not be needed. Other embodiments include both a spindle and a knob, for example, the embodiment illustrated in FIG. **4**A includes a spindle **140**A that houses a link **170**A that includes a locking pin portion **220**A. Depending on the location and orientation of a sloped portion **171**A of link **170**A, one or more actuators, such as button **240**A and actuator shaft **230**A may be included. Assembly and operation of the embodiment illustrated in FIG. **4**A is substantially similar to that described above with reference to FIGS. **4** and **5**.

With reference to the embodiment illustrated in FIGS. **1-5**, a marksman may calibrate the auto-locking device **100** (i.e., reorient the indicator ring **270** relative to the spindle **140**) by loosening the set screws **260** and **262**, which allows the knob **250** and indicator ring **270** to rotate relative to the spindle **140**. After completing the calibration, the set screws **260** and **262** are again tightened to rotationally couple the knob **250** to the spindle **240**.

FIGS. **6-9** illustrate an embodiment including a rotation limiting mechanism comprising an adjustment stop **320**. The adjustment stop **320** includes a handle or knob **322** and a cam surface **324**. By rotating the handle **322**, the cam surface **324** urges a pin **326** in and out of a bore formed in the seat **101**. In other embodiments, the bore may be formed in the device itself. When the pin **326** is in an extended position (FIG. **8**), a protrusion, such as finger **328**, (which may protrude from the knob **250**) interferes with the pin **326** and prevents the knob **250** from making more than one complete rotation about the axis **130**. When the pin **326** is in a retracted position (FIG. **9**), the finger **328** clears the pin **326** and allows the knob **250** to make more than one complete rotation about the axis **130**. For example, the auto-locking device **100** may be capable of making three full revolutions, but the user may limit the travel of the knob **250** to just one revolution by extending or retracting the pin **326**.

FIGS. **10-21** illustrate various views of an auto-locking device **400** according to another embodiment having a different arrangement of actuator shafts and a different rotation limiting mechanism. As shown in FIG. **10**, the auto-locking device **400** is mounted to an optical device **980**, specifically to a main tube **27** of a riflescope. Within the main tube **27** of the riflescope, an inner tube bearing a reticle or lens assembly may be movably mounted perpendicular to a longitudinal tube axis, for example, by a ball-and-socket joint between one end of the inner tube and the main tube **27**. The seat **90** includes a bore **402** sized to receive the auto-locking device **400**. The bore **402** preferably includes threads formed on an interior wall or shoulder of the bore **402** that mate with threads on a spindle base **1**. An aperture **404** is formed at the base of the bore **402** and is sized to receive a threaded plunger or screw **3**. The plunger **3** acts on the inner tube and is constrained from rotating about an axis of rotation **406** (FIG. **14**A) so that rotation of a spindle **2** (into which the plunger **3** is threaded) is translated into linear motion of the plunger **3** along the axis **406**, thereby adjusting a position of the reticle or lens assembly (e.g., the reticle is shifted perpendicular to the tube axis). One or more of the main tube **27**, the inner tube, the optics, or the reticle may take other configurations, for example, those described above with reference to FIGS. **1-5**.

Referring now to FIGS. **10-17**, the plunger **3** is coupled to the inner tube. For example, a rectangular hole in the inner tube may be aligned with the center of the aperture **404** and the rectangular hole may be sized to receive a keyed end of the

plunger **3** to prevent the adjustment plunger **3** from rotating about the axis of rotation **406** (FIG. **14**A). The plunger **3** may be coupled to the inner tube in other ways, such as threaded into the inner tube, welded to the inner tube, or otherwise secured to the inner tube (e.g., via an epoxy). The plunger **3** includes threads at an end of the plunger **3** opposite the keyed end. The threads are preferably sized to mesh with interior threads of the spindle **2** so that the plunger **3** can be threaded into the spindle **2**. Thus, rotation of the spindle **2** about the axis of rotation **406** is translated into linear motion of the plunger **3** along the axis of rotation **406**, thereby adjusting a position of the inner tube (and thus the reticle or optics therein).

The spindle **2** includes a lower base portion **408** and an upper neck portion **410**, and is similar to the spindle described above, including being sandwiched between a flanged lock nut **8** and the spindle base **1**. Spindle **2** is rotatable about the axis of rotation **406** but is constrained from traveling along the axis of rotation **406** by the flanged lock nut **8** and the spindle base **1**. A washer **23**, similar to washer **160** described above, may optionally be included to facilitate rotation of the spindle **2** within a cavity **414** of the spindle base **1**. The upper neck portion **410** of the spindle **2** extends through a central aperture of the flanged lock nut **8** and includes a cavity **416** into which a contact or linkage **4** nests. The spindle **2** also includes a bore **418** into which a clicker or wedge pin **9** extends. Additional details of the linkage **4** and the wedge pin **9** will be described in more detail below.

The spindle base **1** is threaded onto the seat **90** so that the spindle base **1** does not rotate relative to the seat **90** as the spindle **2** rotates about the axis of rotation **406**. A click or lock ring **19** is interposed between a shoulder **420** of the spindle base **1** and the flanged lock nut **8** and is preferably constrained from rotating about the axis of rotation **406**. For example, as the outer threads on the flanged lock nut **8** are threaded into the interior threads of the spindle base **1**, the lock ring **19** is pinched between the shoulder **420** of the spindle base **1** and the flanged lock nut **8** to thereby prevent the lock ring **19** from rotating about the axis **406**. The lock ring **19** may be prevented from rotating about the axis **406** in other ways, such as being secured to the spindle base **1** (e.g., via a weld or epoxy). In addition, a pin may extend between the spindle base **1** and the lock ring **19** to prevent rotation relative to each other. Thus, the spindle base **1**, the lock ring **19**, and the flanged lock nut **8** are anchored to the seat **90** and are prevented from rotating about the axis **406** when the auto-locking device **400** is in a locked or unlocked position.

A locking mechanism includes a linkage **4** nested in the cavity **416** of the spindle **2** between a bottom surface **422** of the cavity **416** and a spindle retaining nut **6**. The retaining nut **6** is provided with outer threads **424** that mate with inner threads **426** of the neck **410** of the spindle **2**. The retaining nut **6** limits the travel of the linkage **4** along the axis **406**. The linkage **4** includes a bore **426** sized to receive a spring **7**, which is provided to bias the linkage **4** toward a locked position, for example, away from the bottom surface **422** of the cavity **416**. The linkage **4** also includes an offset bore **430**, which includes interior threads sized to mate with a threaded portion **432** of a locking pin **5**. Locking pin **5** is assembled with linkage **4** to form a link. Other suitable links, such as those describe above, may be used. A protrusion **434** of the linkage **4** extends through an aperture **436** of the retaining nut **6** for interaction with a pair of actuator shafts **17**. Thus, the linkage **4** is configured for movement between a first (locked) position (FIGS. **14**A, **18**, and **20**) and a second (unlocked) position (FIGS. **19** and **21**). The locking pin **5** travels along

with the linkage **4** as the link moves between the first and second positions along the axis **406**.

The locking pin **5** includes a circumferential groove **442** into which a butt **444** of the wedge pin **9** can enter, for example, as described above. When the locking pin **5** is positioned as shown in FIG. **14**A, the locking pin **5** urges a wedge portion **446** of the wedge pin **9** to engage an engagement surface **448** of the lock ring **19**. When the locking pin **5** is positioned as shown in FIGS. **19** and **21**, the circumferential groove **442** is aligned with the wedge pin **9**. As the spindle **2** rotates about the axis of rotation **406**, the wedge portion **446** of the wedge pin **9** is permitted to disengage the regularly spaced apart features of the engagement surface **448** because the butt **444** of the wedge pin **9** can enter the circumferential groove **442** against the bias of spring **10**. According to one embodiment, the spring **10** biases the wedge pin **9** toward the lock ring **19**. The wedge pin **9** may provide tactile feedback to the user when lock ring **19** also serves as a click ring by including optional regularly spaced apart features on or in the engagement surface **448** and the wedge pin **9** engages and disengages such regularly spaced apart features **449**. When an optional click ring is included, or lock ring **19** is also configured as a click ring, a user can determine an angular rotation of the spindle **2** by counting the number of clicks.

A knob **11** is installed over the spindle **2** and the spindle base **1**. The knob **11** includes a set of opposed threaded bores **450** sized to receive a pair of threaded set screws **14**. Any number of set screws may be provided around the axis **406**. As illustrated in FIG. **14**A, the set screws **14** rotationally couple the knob **11** to the neck **410** of the spindle **2**. A tool, such as a hex key, can be used to tighten the set screws **14** such that the screws **14** bear against the neck **410** of the spindle **2**. Similarly, the tool can be used to loosen the set screws **14** so rotation of the knob **11** does not cause the spindle **2** to rotate about the axis **406**.

A circumferential groove **452** is formed in spindle **2** and is sized to accommodate a snap ring **26**. The snap ring **26** is compressed when inserted into the circumferential groove **452** so that the snap ring **26** will expand into a circumferential groove **454** or **455** formed in the knob **11** when either circumferential groove **454** or **455** is aligned with the circumferential groove **452** (which will be described in more detail with reference to FIGS. **18-21** below).

An indicator **12** slips over a base of the knob **11** and is typically marked with a scale around its circumference that allows the user to take a reading with respect to an index mark on the main tube **27**. The indicator **12** may be provided with a notch that mates with a boss on the knob **11** so that the indicator **12** can be aligned with the knob **11**, for example, as described above with reference to FIGS. **1-5**. As a lock ring **456** is threaded onto the base of the knob **11**, the indicator **12** is sandwiched between a shoulder **458** of the knob **11** and the lock ring **456**.

A set of actuator shafts **17** are inserted into a set of opposed bores **460** formed in the knob **11**. The actuator shafts **17** include a threaded portion **462** that threads into a threaded bore **464** of buttons **16** (which are shown having a C-shape). A set of springs **15** are provided to bias the buttons **16** toward an extended position (as shown in FIG. **14**A). The actuator shafts **17** are provided with a curved or sloped portion **466** that interacts with a curved or sloped portion **468** of the linkage **4**. Other suitable shapes or contours may be provided, such as those described with reference to FIGS. **1-5**. Alternatively, a single actuator may be used.

As shown in FIG. **17**, the actuator shafts may be in-line with each other, which may help avoid play between the actuator shafts **17** and the linkage **4**. In addition, the actuator

shafts **17** may be offset from each other as described with reference to FIGS. **1-5**. The buttons **16** can slide over each other (as shown in FIGS. **10**, **15**, and **16**) or the buttons **16** can be spaced apart (as shown in FIGS. **1-5**). Alternatively, a single actuator may be used.

The operation of the auto-locking device **400** will now be described with reference to FIGS. **14**A, **18**, and **20** (illustrating a locked configuration) and FIGS. **19** and **21** (illustrating an unlocked configuration). The user actuates or unlocks the auto-locking device **400** by grasping and squeezing or radially pinching the buttons **16** which causes the actuator shafts **17** to move toward the linkage **4** against the bias of the springs **15**. The curved portion **466** of the actuator shafts **17** interact with the curved portion **468** of the linkage **4** to cause the linkage **4** to move with the locking pin **5** (which is coupled to the linkage **4**) against the bias of spring **7**. In other words, the linkage **4** is configured to convert radial motion of the actuator shafts **17** into axial motion of the locking pin **5**. Other suitable curved or sloped portions may be included on the actuator shafts **17** or on the linkage **4**. After the linkage **4** has moved to a locked position, for example, adjacent or abutting the bottom surface **422** of the cavity **416**, the circumferential groove **442** of the locking pin **5** is aligned with the wedge pin **9**. As previously noted, the wedge pin **9** may be biased by the spring **10** to engage (or disengage) the engagement surface **448** of the lock ring **19**. As the user rotates the knob **11**, the spindle **2** rotates about the axis **406** along with the wedge pin **9**. When the circumferential groove **442** is aligned with the wedge pin **9**, the butt **444** of the wedge pin **9** can enter the circumferential groove **442** to permit spindle **2** to rotate and wedge pin **9** to engage and disengage the regularly spaced apart features formed in or on the engagement surface **448**. Rotation of the spindle **2** causes the plunger **3** to move along the axis **406** (thereby adjusting a position of the inner tube).

When the user releases the buttons **16**, the springs **15** cause the buttons **16** and the actuator shafts **17** to move to the position illustrated in FIGS. **14**A, **18**, and **20**. Once the actuator shafts **17** are out of the way, the spring **7** causes the linkage **4** and the locking pin **5** to move upward toward the position shown in FIGS. **14**A, **18**, and **20**. In other embodiments, springs **15** are not included because the spring **7** is sufficiently strong to cause linkage **4** and buttons **16** to move to the locked position. Because the circumferential groove **442** is no longer aligned with the wedge pin **9**, the locking pin **5** causes the wedge shaped portion **446** of the wedge pin **9** to engage at least one of the regularly spaced apart features **449** of the lock ring **19**. Because the lock ring **19** is anchored to the main tube **27**, the wedge pin **9** (which is coupled to the spindle **2**) prevents the knob **11** from rotating about the axis **406** (i.e., the knob **11** is automatically locked when an external force on the buttons **16** is removed).

FIGS. **18-21** also illustrate how the knob **11** can be adjusted between a first position in which the knob **11** is permitted one revolution of rotational travel (FIGS. **18** and **19**) and a second position in which the knob **11** is permitted multiple revolutions of rotational travel (FIGS. **20** and **21**). To move the knob **11** from the first position to the second position, the user loosens the set screws **14** and pulls the knob **11** up then retightens set screws **14**. Conversely, to move the knob **11** from the second position to the first position, the user loosens the set screws **14** and pushes the knob **11** down. The user can pull the knob **11** up to remove the snap ring **26** from the circumferential groove **455** by compressing the snap ring **26** into circumferential groove **452** (of the spindle **2**). The user continues to pull up until the circumferential groove **452** is aligned with the circumferential groove **454** (of the knob **11**). After the circumferential grooves **452** and **454** are aligned, the snap ring **26** enters (e.g., expands and snaps into) the circumferential groove **454**, thus letting the user know to stop pulling up (if the user keeps pulling up, the user can remove the knob **11**). In other words, when the circumferential grooves **452** and **454** are aligned and the snap ring **26** snaps into the circumferential groove **454**, a finger **500** (FIGS. **10** and **11**A) or other protrusion of the knob **11** will clear a pin **28** (which is inserted into a bore of the seat **90** or of the device), which allows the knob **11** to make more than one complete rotation about the axis **406**. For example, the auto-locking device **400** may be capable of making three full revolutions, but the user may selectively limit the travel of the knob **11** to just one revolution by positioning the knob **11** in the first position (where the snap ring **26** expands and snaps into circumferential groove **455** as illustrated in FIGS. **18** and **19**). After the user pulls the knob **11** upwards to the second position (or conversely pushes the knob **11** downwards toward the first position), the user tightens the set screws **14** (thereby coupling the knob **11** to the spindle **2** for rotation therewith). Inclusion of snap ring **26** and circumferential grooves **452**, **454**, and **455** is optional, for example circumferential groove **454** may be omitted, circumferential groove **455** may be omitted, and all of snap ring **26** and circumferential grooves **452**, **454**, and **455** may be omitted in different embodiments. A user may visually inspect the clearance between a protrusion of the knob **11**, such as finger **500**, and a non-rotating portion, such as pin **28** in embodiments where circumferential groove **454** is omitted, circumferential groove **455** is omitted, or all of snap ring **26** and circumferential grooves **452**, **454**, and **455** are omitted.

A marksman may calibrate the auto-locking device **400** (i.e., reorient the indicator **12** relative to the spindle **2**) by loosening the set screws **14**, which allows the knob **11** and indicator **12** to rotate relative to the spindle **2**. After completing the calibration, the set screws **14** are again tightened to rotationally couple the knob **11** to the spindle **2**.

As described with reference to FIGS. **1-5**, any number of optional seals, such as O-rings **18**, **21**, **22**, **24**, **600** and **602** (FIG. **10**), may be provided to keep out contamination. Optionally, thread lock materials or waterproofing materials, such as LocTite® or Teflon® tape may be included at any or all of the threaded interfaces (but not between the plunger **3** and spindle **2**). Any of the foregoing components may be made of metal, plastic, or another suitable material.

In addition to the variations and combinations previously presented, other arrangements and features are disclosed in U.S. Patent Publication No 2009/0205461 which is hereby incorporated by reference in its entirety.

In one example, a dial comprises a selectively lockable mechanism including, (A) a linkage coupled to the spindle for rotation therewith such that the linkage is moveable along the axis of rotation between the locked position and the unlocked position, wherein the linkage includes a first sloped surface, (B) a locking pin extending from the linkage, (C) a wedge pin slidably mounted in the spindle, and (D) a lock ring supported by the device such that the lock ring is not rotatable about the axis of rotation. The locking pin is configured to inhibit the wedge pin from moving away from the lock ring when the linkage is in the locked position and to facilitate movement of the wedge pin away from the lock ring when the linkage is in the unlocked position and the spindle is rotated about the axis of rotation. Also, the wedge pin and the lock ring are configured to non-moveably engage each other when the linkage is in the locked position, and the wedge pin and the lock ring are configured to moveably engage each other when the linkage is in the unlocked position. The dial also comprises and actuator including (E) a button slidably engaging the knob,

wherein the button is configured to move substantially transverse to the axis of rotation, and (F) an actuator shaft coupled to the button for movement therewith, wherein the actuator shaft includes a second sloped surface engaging the first sloped surface of the linkage, and wherein the actuator shaft extends from the button through the knob to a position proximate the axis of rotation. Also, the second sloped surface of the actuator shaft is configured to exert force on the first sloped surface of the linkage in response to movement of the button substantially transverse to the axis of rotation, and the linkage is configured to move along the axis of rotation to the unlocked position in response to the second sloped surface exerting force on the first sloped surface.

In another example, the dial described in the preceding paragraph further comprises a spindle base interposed between the threaded spindle and the seat, the spindle base coupled to the seat and including a sidewall extending away from the device, the sidewall defining a recess into which the spindle nests; and a retaining nut coupled to the spindle base to retain a portion of the spindle between the retaining nut and the spindle base to constrain the spindle from traveling along the axis of rotation but permitting the spindle to rotate about the axis of rotation.

The terms and descriptions used above are set forth by way of illustration only and are not meant as limitations. Those skilled in the art will recognize that many variations can be made to the details of the above-described embodiments without departing from the underlying principles of the invention. The scope of the present invention should, therefore, not be limited to the above specific examples, but is defined by the claims below.

The invention claimed is:

1. An auto-locking adjustment device for an optical device, comprising:

an engagement surface fixed relative to the optical device;

a spindle rotatably supported on the optical device for rotation about an axis and relative to the optical device and the engagement surface, the spindle operatively coupled to an adjustable portion of the optical device to thereby adjust the adjustable portion in response to rotation of the spindle;

a locking mechanism carried by the spindle for rotation therewith, the locking mechanism switchable between a locked condition and an unlocked condition; and

a button carried by the spindle for rotation therewith and manually depressible transverse to the axis, the button mechanically driving the locking mechanism such that manually depressing the button switches the locking mechanism from the locked condition, wherein the locking mechanism interlocks with the engagement surface and prevents rotation of both the spindle and the button relative to the optical device, to the unlocked condition, wherein both the spindle and the button are rotatable about the axis relative to the optical device and the engagement surface.

2. The adjustment device of claim **1**, further comprising a linkage carried by the spindle for rotation therewith and moveable along the axis relative to the spindle in response to depressing and releasing the button, to thereby switch the locking mechanism between the locked and unlocked conditions.

3. The adjustment device of claim **1**, further comprising a means for biasing the locking mechanism to the locked condition, the means for biasing being opposed by depressing the button.

4. The adjustment device of claim **1**, wherein:

the engagement surface includes multiple regularly spaced detents; and

when the locking mechanism is in the unlocked condition, a portion of the locking mechanism rides across the detents as the spindle is rotated to provide tactile feedback indicating the extent of rotation of the spindle.

5. The adjustment device of claim **1**, wherein the locking mechanism includes:

a linkage coupled to the spindle for rotation therewith and moveable along the axis of rotation relative to the spindle between the locked condition and the unlocked condition;

a wedge pin carried by the spindle for rotation therewith and slidably mounted to the spindle for movement relative to the spindle transverse to the axis; and

wherein the linkage bears against the wedge pin when the linkage is in the locked condition to prevent the wedge pin from moving relative to the spindle and the engagement surface, to thereby prevent the spindle from rotating relative to the optical device.

6. The adjustment device of claim **5**, further comprising a means for biasing the linkage into the locked condition.

7. The adjustment device of claim **5**, further comprising a means for biasing the wedge pin toward the engagement surface.

8. The adjustment device of claim **5**, wherein the locking mechanism further includes a locking pin having a groove that aligns with the wedge pin when the linkage is in the unlocked condition, the groove receiving a portion of the wedge pin as the spindle is rotated.

9. The adjustment device of claim **1**, wherein the spindle is constrained from moving along the axis.

10. The adjustment device of claim **1**, further comprising a mechanical coupling operatively connected to the spindle and constrained so that rotation of the spindle about the axis causes the mechanical coupling to move along a predetermined path relative to the axis, and the mechanical coupling couples the spindle to the adjustable portion of the optical device to thereby adjust a position of the adjustable portion of the optical device in response to rotation of the spindle.

11. The adjustment device of claim **1**, further comprising a plunger threadably attached to the spindle and restrained from rotating about the axis relative to the optical device, such that rotation of the spindle about the axis causes the plunger to translate linearly along the axis, the plunger bearing against the adjustable portion of the optical device.

12. An optical device including the adjustment device of claim **11**, wherein the optical device is a weapon aiming device comprising:

an outer tube on which the adjustment device is mounted; and

the adjustable portion, including an inner tube positioned within the outer tube and movable therein, and the plunger drives movement of the inner tube in response to rotation of the spindle, to thereby adjust an elevation or windage of the weapon aiming device.

13. The adjustment device of claim **1**, wherein the button includes:

a first button and

a second button opposing the first button,

wherein the first and second buttons are moved toward each other when manually depressed and are biased away from each other.

14. The adjustment device of claim **13**, further comprising an actuator shaft attached to each of the first and the second buttons and extending toward the axis, wherein each actuator

shaft includes a sloped surface that bears against the locking mechanism to drive the locking mechanism.

15. The adjustment device of claim **14**, wherein each of the first and the second actuator buttons must be depressed radially toward the axis such that an outer surface of each button is located inward of an outer surface of the spindle to switch the locking mechanism to the unlocked condition.

16. The adjustment device of claim **14**, wherein the two actuator shafts are linearly aligned with each other.

17. The adjustment device of claim **14**, wherein the two actuator shafts are offset from each other.

18. The adjustment device of claim **1**, further comprising a knob installed over the spindle and coupled to the spindle for rotation therewith, and wherein the button is slidably supported on the knob.

19. The adjustment device of claim **18**, further comprising an indicator ring mounted on the knob for rotation therewith to provide a visual indication of the amount of rotation of the knob, and wherein the knob is selectively coupled to the spindle for selecting either rotation with the spindle or rotation relative to the spindle.

20. The adjustment device of claim **19**, further comprising a set screw selectively securing the knob to the spindle.

21. The adjustment device of claim **18**, further comprising an actuator shaft attached to the button and extending from the button through a bore in the knob to a position proximate the axis.

22. The adjustment device of claim **1**, further comprising a rotation- limiting adjustment stop that is movable relative to the spindle between a stop position and a non-stop position, wherein the rotation-limiting adjustment stop limits rotation of the spindle to one full rotation when the rotation-limiting adjustment stop is in the stop position.

23. An optical device inc tiding the adjustment device of claim **1**.

24. An auto-locking adjustment device for an optical device, comprising:

an engagement surface fixed relative to the optical device;

a spindle rotatably supported on the optical device for rotation about an axis and relative to the optical device and the engagement surface, the spindle operatively coupled to an adjustable portion of the optical device to thereby adjust the adjustable portion in response to rotation of the spindle;

a locking mechanism carried by the spindle for rotation therewith, the-locking mechanism switchable between a locked condition and an unlocked condition;

a first and an opposing second button attached to the spindle for rotation therewith and manually depressible transverse to the axis, wherein the first and second buttons are moved toward each other when manually depressed and are biased away from each other, at least one of the first and second buttons mechanically driving the locking mechanism such that manually depressing the at least one of the first and second buttons switches the locking mechanism from the locked condition, wherein the locking mechanism interlocks with the engagement surface and prevents rotation of both the spindle and the button relative to the optical device, to the unlocked condition, wherein both the spindle and button are rotatable about the axis relative to the optical device and the engagement surface; and

an actuator shaft attached to each of the first and the second buttons and extending toward the axis, wherein each actuator shaft includes a sloped surface that bears against the locking mechanism to drive the locking mechanism.

25. An auto-locking adjustment device for an optical device, comprising:

an engagement surface fixed relative to the optical device;

a spindle rotatably supported on the optical device for rotation about an axis and relative to the optical device and the engagement surface, the spindle operatively coupled to an adjustable portion of the optical device to thereby adjust the adjustable portion in response to rotation of the spindle;

a locking mechanism carried by the spindle for rotation therewith, the locking mechanism switchable between a locked condition and an unlocked condition;

a knob installed over the spindle and coupled to the spindle for rotation therewith;

a button carried by the spindle for rotation therewith and slidable supported on the knob, the button manually depressible transverse to the axis, the button mechanically driving the locking mechanism such that manually depressing the button switches the locking mechanism from the locked condition, wherein the locking mechanism interlocks with the engagement surface and prevents rotation of both the knob and the button relative to the optical device, to the unlocked condition, wherein both the knob and the button are rotatable about the axis relative to the optical device and the engagement surface; and

an actuator shaft attached to the button and extending from the button through a bore in the knob to a position proximate the axis.

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